Visual Analysis of Concept Change and Information Diffusion

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Plenary Speech at InSciT2006. Merida, Spain. October 26, 2006

Understanding the Structure, the Growth, and Spread of Information and Knowledge

- **How often do we need to answer these questions?**
  - **(as a scientist, a scholar, an evaluator, a policy maker, a doctoral student, a librarian, etc.)**
- **What tools are available for such needs?**
- **How effective are they?**

1. What is the hottest topic at time T0?
2. What have been the hot topics between time Ta and Tb? (A Timeline - Temporal)
3. What are the major turning points between time Ta and Tb? (Turning points - Structural)
4. How did knowledge associated with these turning points spread? (Diffusion - Spatial)
5. How can we differentiate various perspectives and views based on a large volume of inputs? (Sense-Making - Semantics)

A quick CiteSpace demo
Topic: Terrorism
Time span: 1996-2003

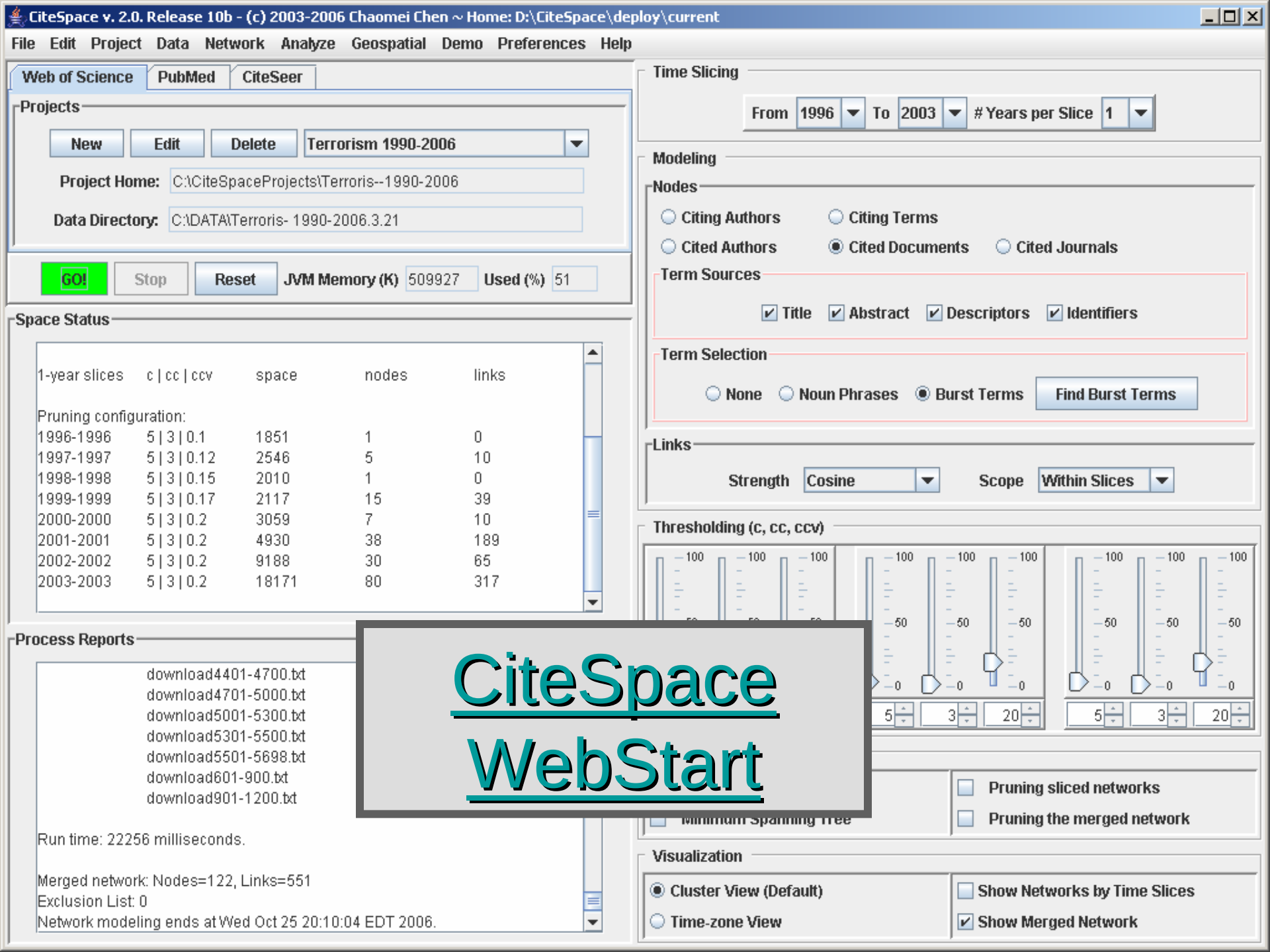
Q1: Current hot topic?

Q2: Previous hot topic?

Q3: Turning point?

Q4: Transition path?

1. **What is the most studied topic in the area of TERRORISM RESEARCH?**
2. **What topic was predominant before this one?**
3. **What EVENT/WORK caused the shift of focus?**
4. **What is the intellectual path that underlined such a transition?**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Web of Science PubMed CiteSeer
Projects
New Edit Delete Terrorism 1990-2006
Project Home: C:\CiteSpaceProjects\Terroris--1990-2006
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GO! Stop Reset JVM Memory (K) 509927 Used (%) 51
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1-year slices c | cc | ccv space nodes links
Pruning configuration:
1996-1996 5 | 3 | 0.1 1851 1 0
1997-1997 5 | 3 | 0.12 2546 5 10
1998-1998 5 | 3 | 0.15 2010 1 0
1999-1999 5 | 3 | 0.17 2117 15 39
2000-2000 5 | 3 | 0.2 3059 7 10
2001-2001 5 | 3 | 0.2 4930 38 189
2002-2002 5 | 3 | 0.2 9188 30 65
2003-2003 5 | 3 | 0.2 18171 80 317
Process Reports
download4401-4700.txt
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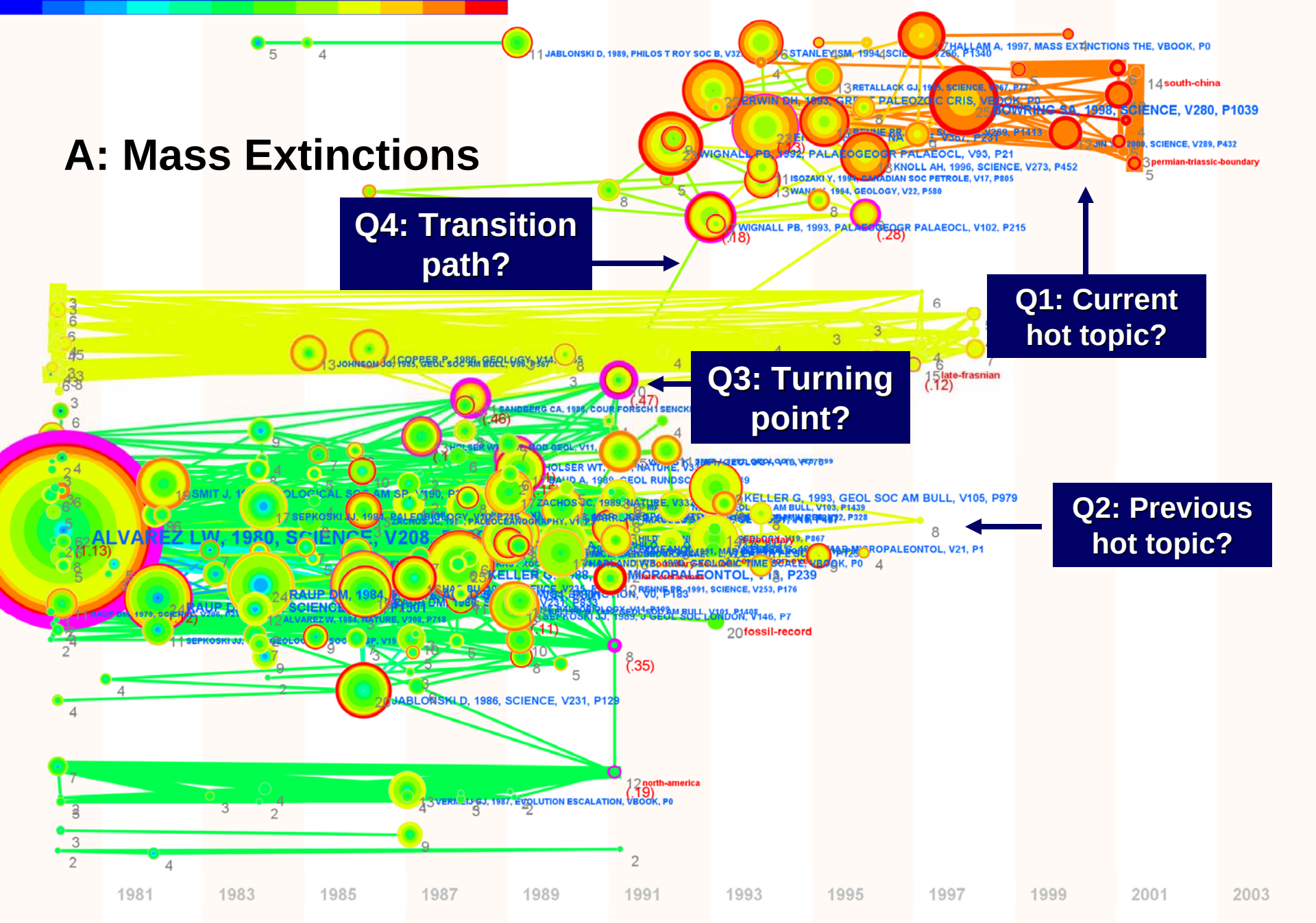
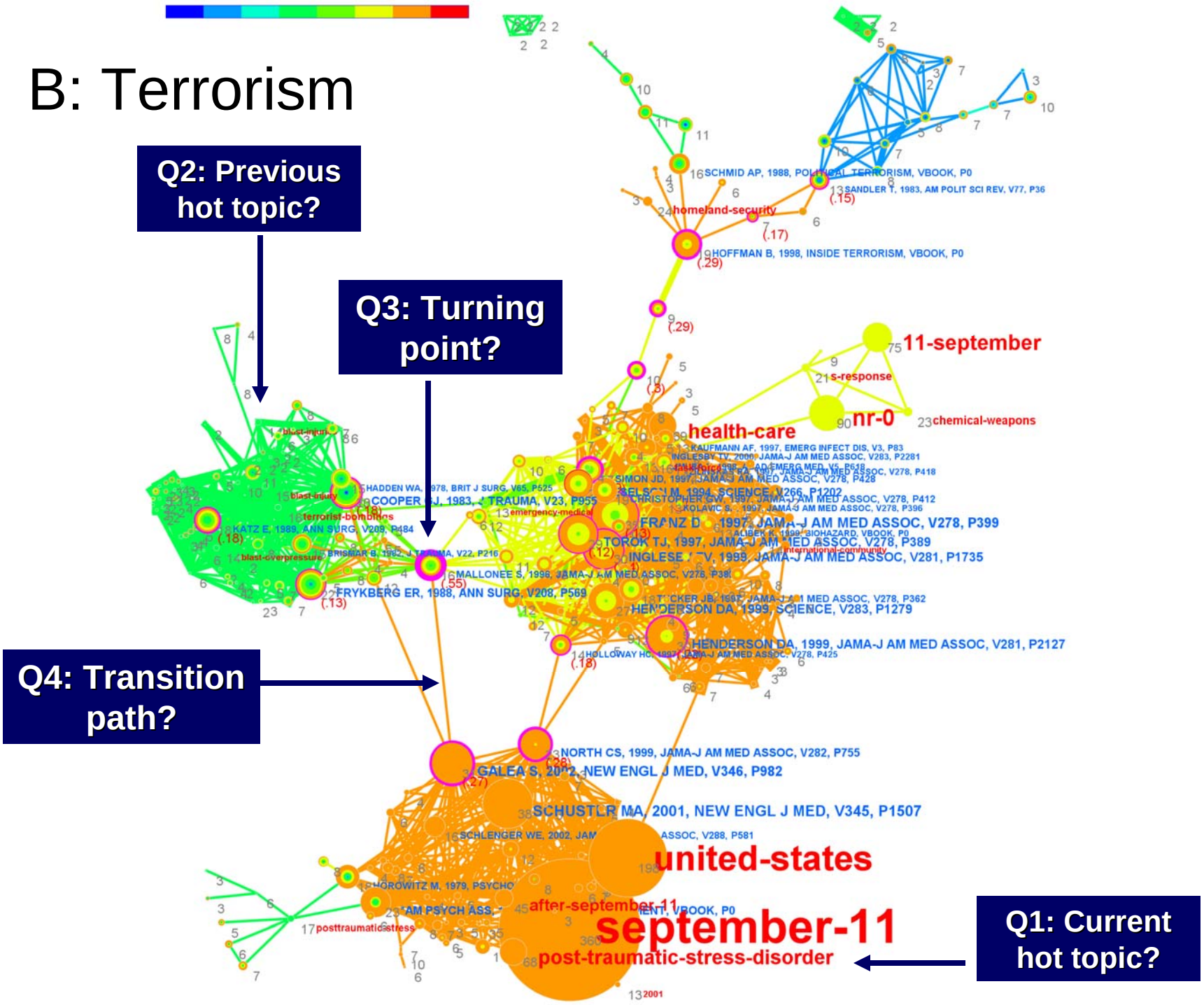
download5301-5500.txt
download5501-5698.txt
download601-900.txt
download901-1200.txt
Run time: 22256 milliseconds.
Merged network: Nodes=122, Links=551
Exclusion List: 0
Network modeling ends at Wed Oct 25 20:10:04 EDT 2006.
Time Slicing
From 1996 To 2003 # Years per Slice 1
Modeling
Nodes
Citing Authors Citing Terms
Cited Authors Cited Documents Cited Journals
Term Sources
Title Abstract Descriptors Identifiers
Term Selection
None Noun Phrases Burst Terms Find Burst Terms
Links
Strength Cosine Scope Within Slices
Thresholding (c, cc, ccv)
Pruning sliced networks
Pruning the merged network
Visualization
Cluster View (Default)
Time-zone View
Show Networks by Time Slices
Show Merged Network
CiteSpace
WebStart

Finding Tipping Points

A: Mass Extinctions



B: Terrorism


Q2: Previous hot topic?
Q3: Turning point?
Q4: Transition path?
Q1: Current hot topic?
SCHMID AP, 1988, POLITICAL TERRORISM, VBOOK, P0
SANDLER T, 1983, AM POLIT SCI REV, V77, P36
homeland-security
HOFFMAN B, 1998, INSIDE TERRORISM, VBOOK, P0
11-september
s-response
nr-0
chemical-weapons
health-care
KAUFMANN AF, 1997, EMERG INFECT DIS, V3, P83
INGLESBY TV, 2000, JAMA-J AM MED ASSOC, V283, P2281
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CHRISTOPHER GW, 1997, JAMA-J AM MED ASSOC, V278, P412
KOLAVIC S, 1997, JAMA-J AM MED ASSOC, V278, P396
FRANZ D, 1997, JAMA-J AM MED ASSOC, V278, P399
TOROK TJ, 1997, JAMA-J AM MED ASSOC, V278, P389
INGLESE J, 1999, JAMA-J AM MED ASSOC, V281, P1735
HENDERSON DA, 1999, SCIENCE, V283, P1279
HENDERSON DA, 1999, JAMA-J AM MED ASSOC, V281, P2127
HADDEN WA, 1978, BRIT J SURG, V65, P525
COOPER GJ, 1983, J TRAUMA, V23, P955
KATZ E, 1989, ANN SURG, V209, P484
BRISMAR B, 1982, J TRAUMA, V22, P216
MALLONEE S, 1996, JAMA-J AM MED ASSOC, V278, P38
FRYKBERG ER, 1988, ANN SURG, V208, P569
TUCKER JB, 1997, JAMA-J AM MED ASSOC, V278, P362
HOLLOWAY HC, 1997, JAMA-J AM MED ASSOC, V278, P425
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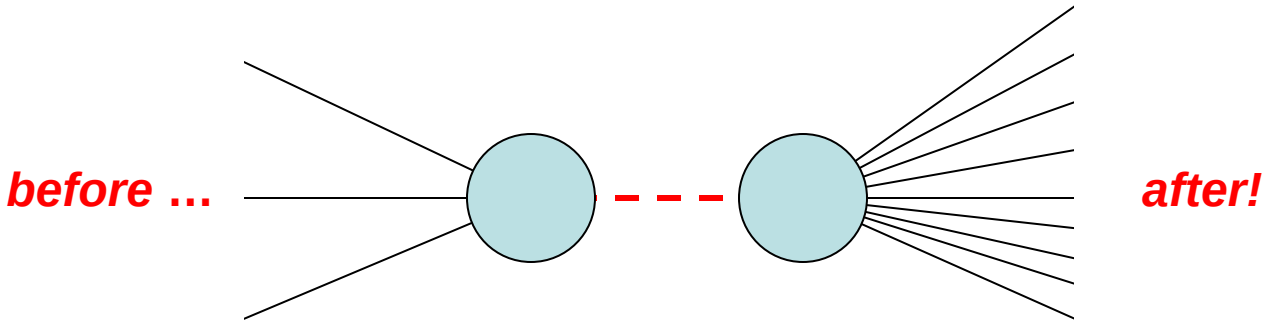
terrorist-bombings
blast-overpressure
emergency-medical
international-community
NORTH CS, 1999, JAMA-J AM MED ASSOC, V282, P755
GALEA S, 2002, NEW ENGL J MED, V346, P982
SCHUSTER MA, 2001, NEW ENGL J MED, V345, P1507
SCHLENGER WE, 2002, JAM ASSOC, V288, P581
HOROWITZ M, 1979, PSYCHO
AM PSYCH ASS,
posttraumaticstress
after-september-11
september-11
post-traumatic-stress-disorder
united-states
2001

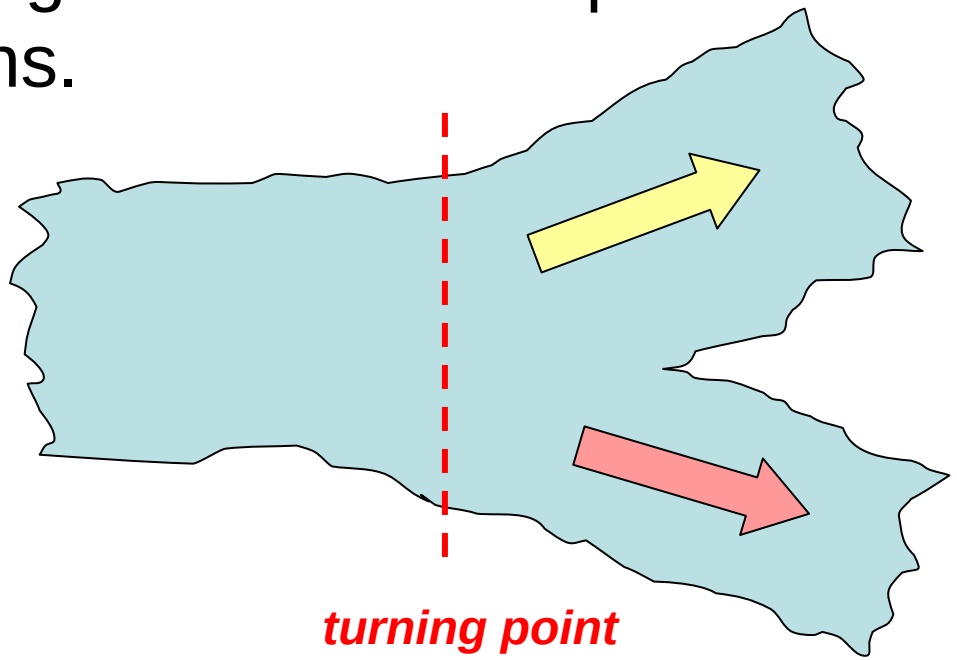
Structural and Temporal Analysis of Scientific Literature

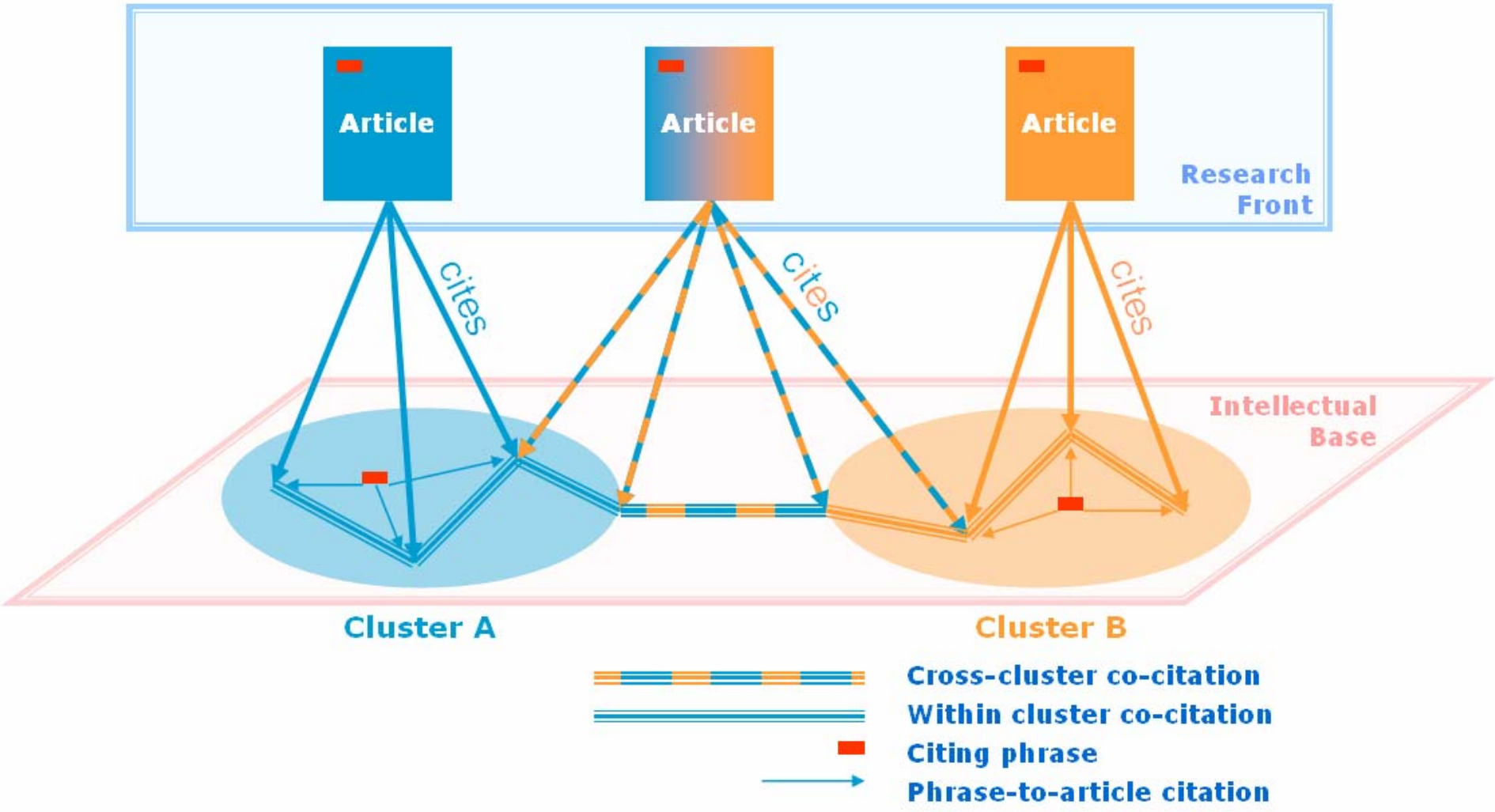
- Emerging themes
- Intellectual turning points



Paradigm Shift

- Normative
  - Citations reflect intellectual values.
- Recentness
  - Citations register new concepts and new associations.

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Article
Article
Research Front
cites
cites
cites
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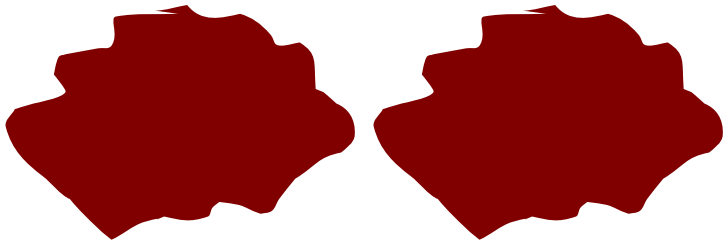
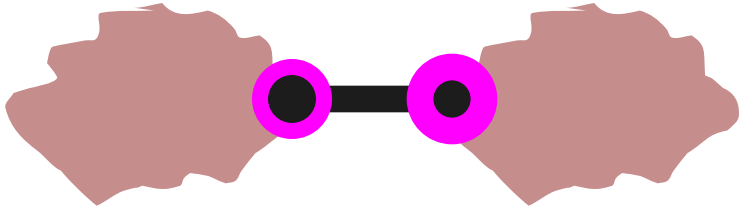
Cluster A
Cluster B
Cross-cluster co-citation
Within cluster co-citation
Citing phrase
Phrase-to-article citation

Expected Patterns

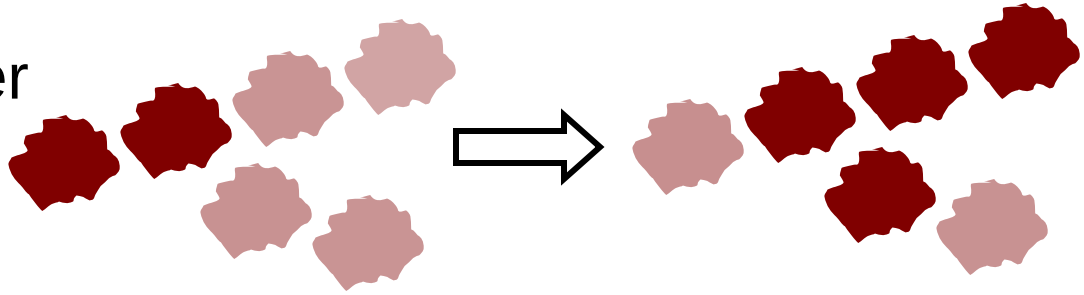
- Thematic grouping



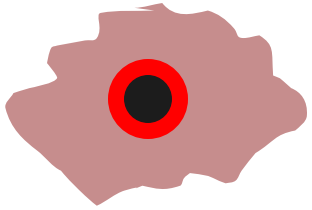
- Intellectual turning points



- Thematic change over time

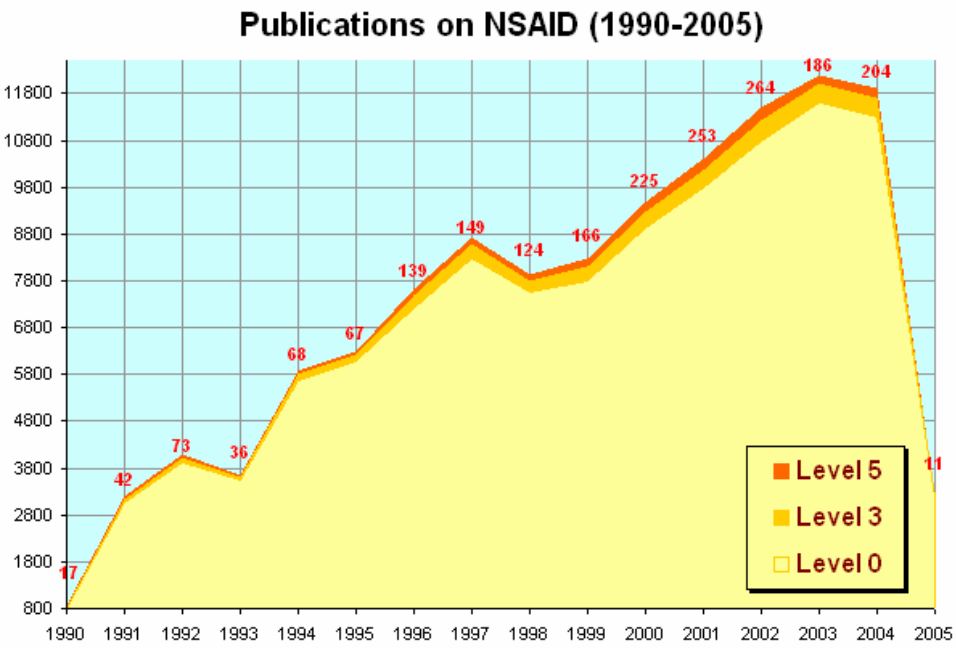


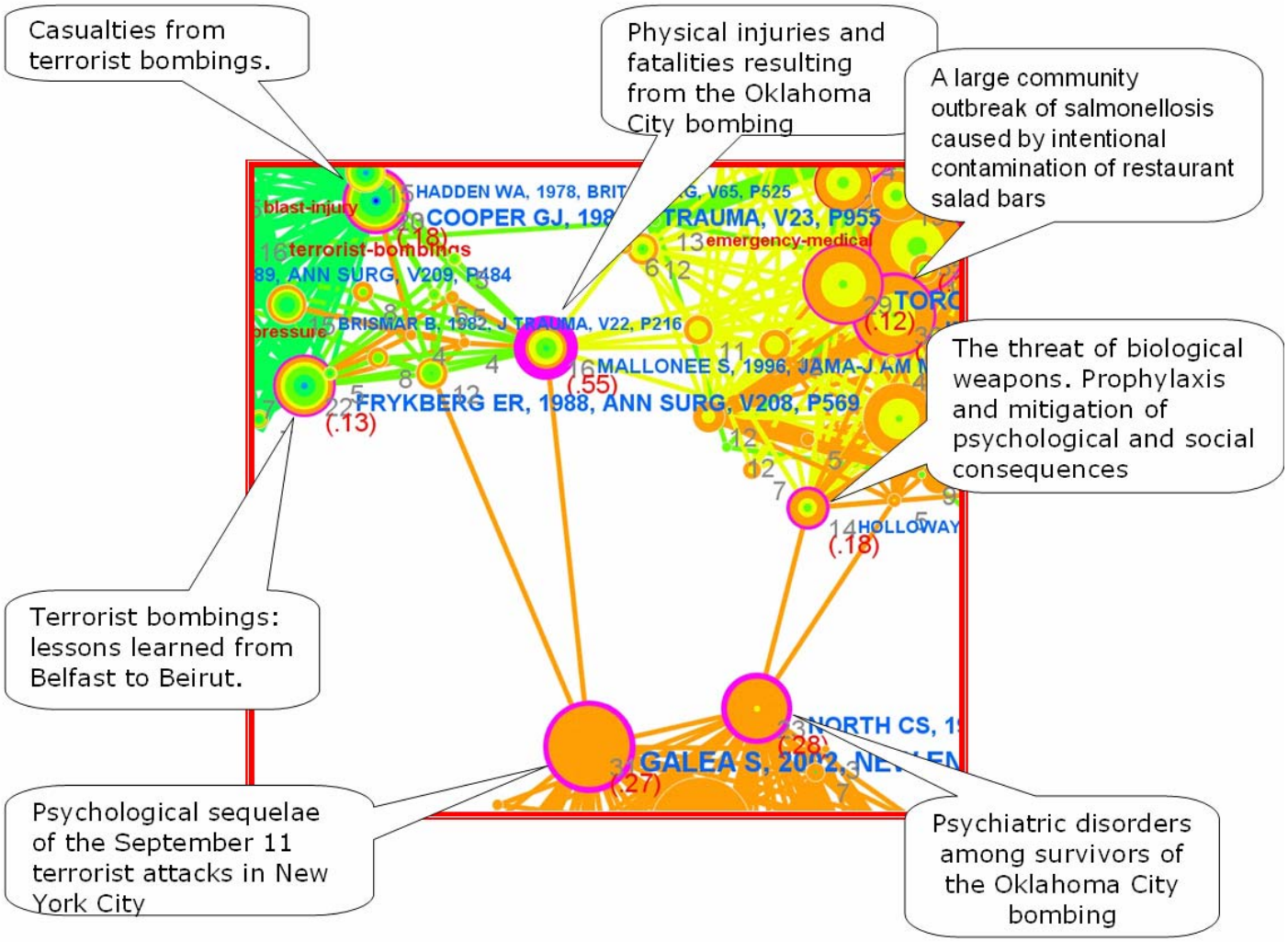
- Abrupt changes associated with triggers



Why Scientists Cite?

- Normative View
  - Citations are made because of the intellectual values of cited works.
  - They should not be affected by social and cultural characteristics such as race, gender, or academic rank.




Casualties from terrorist bombings.
Physical injuries and fatalities resulting from the Oklahoma City bombing
A large community outbreak of salmonellosis caused by intentional contamination of restaurant salad bars
The threat of biological weapons. Prophylaxis and mitigation of psychological and social consequences
Terrorist bombings: lessons learned from Belfast to Beirut.
Psychological sequelae of the September 11 terrorist attacks in New York City
Psychiatric disorders among survivors of the Oklahoma City bombing
HADDEN WA, 1978, BRIT
COOPER GJ, 198
TRAUMA, V23, P955
emergency-medical
blast-injury
terrorist-bombings
89, ANN SURG, V209, P484
BRISMAR B, 1982, J TRAUMA, V22, P216
MALLONEE S, 1996, JAMA-J AM
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HOLLOWAY
GALEA S, 20
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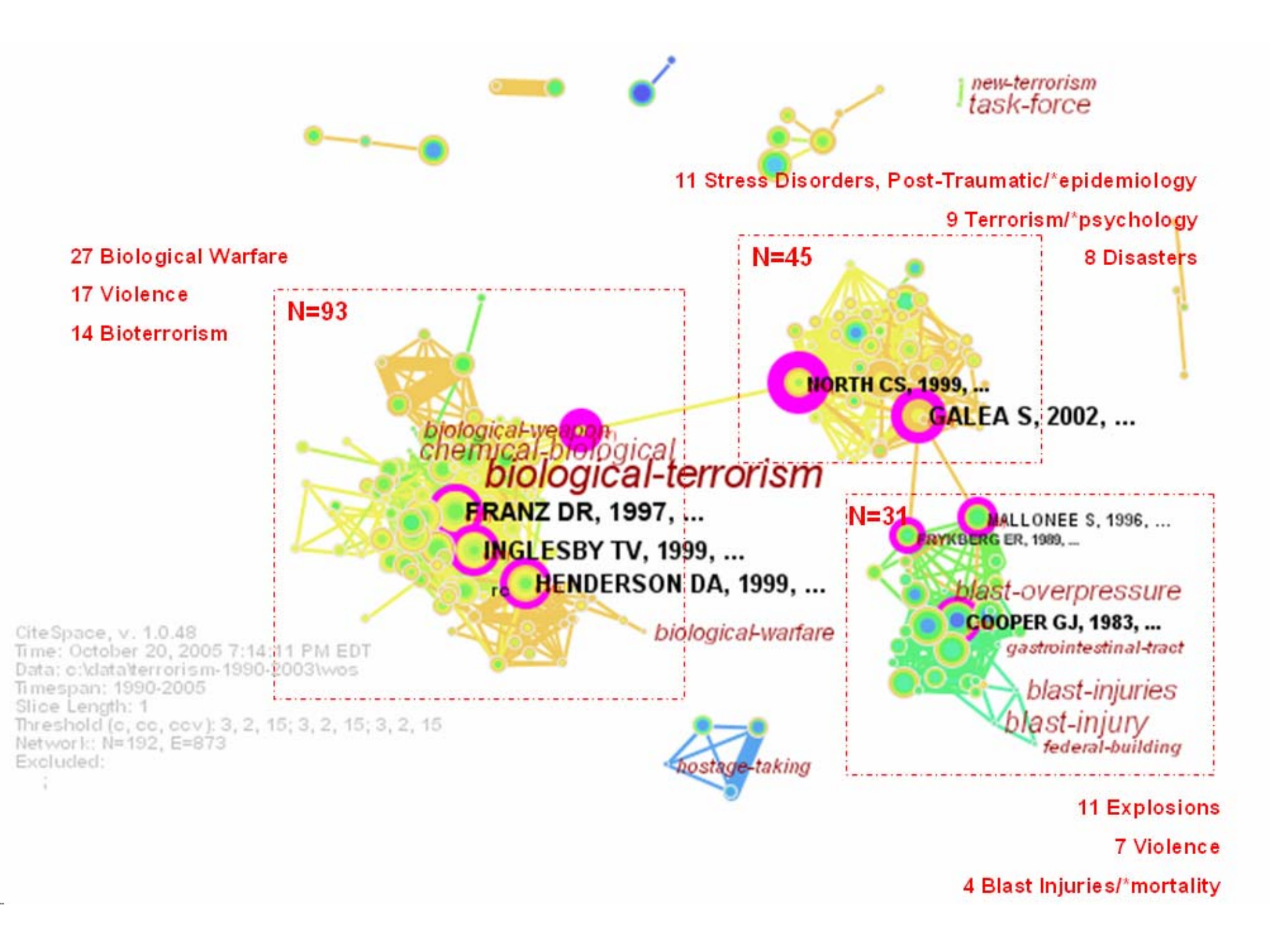
(.12)
(.28)
(.27)


new-terrorism
task-force
11 Stress Disorders, Post-Traumatic/*epidemiology
9 Terrorism/*psychology
8 Disasters
27 Biological Warfare
17 Violence
14 Bioterrorism
N=45
N=93
NORTH CS, 1999, ...
GALEA S, 2002, ...
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chemical-biological
biological-terrorism
FRANZ DR, 1997, ...
INGLESBY TV, 1999, ...
HENDERSON DA, 1999, ...
rc
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N=31
HALLONEE S, 1996, ...
FRYKBERG ER, 1999, ...
blast-overpressure
COOPER GJ, 1983, ...
gastrointestinal-tract
blast-injuries
blast-injury
federal-building
hostage-taking
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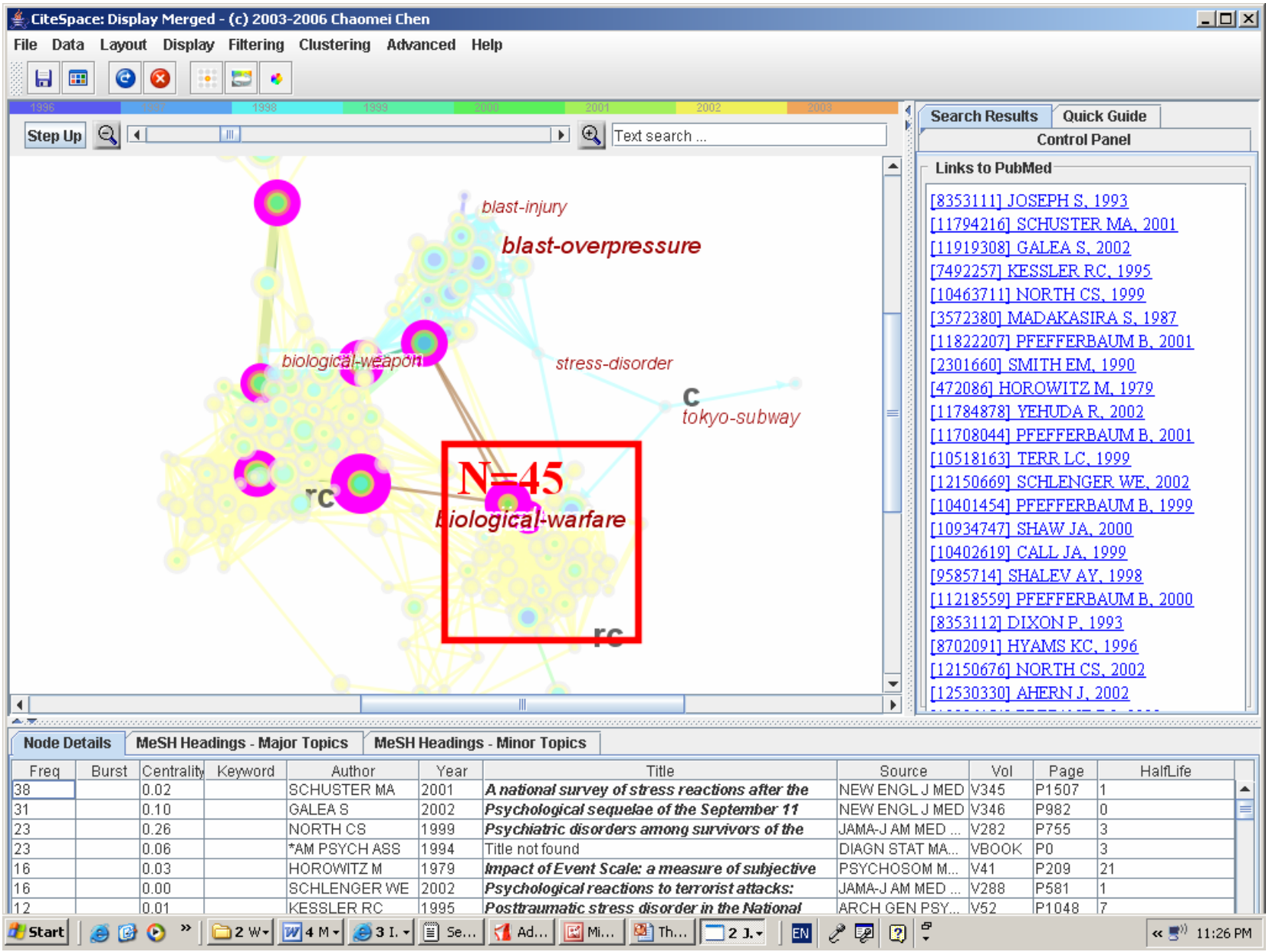
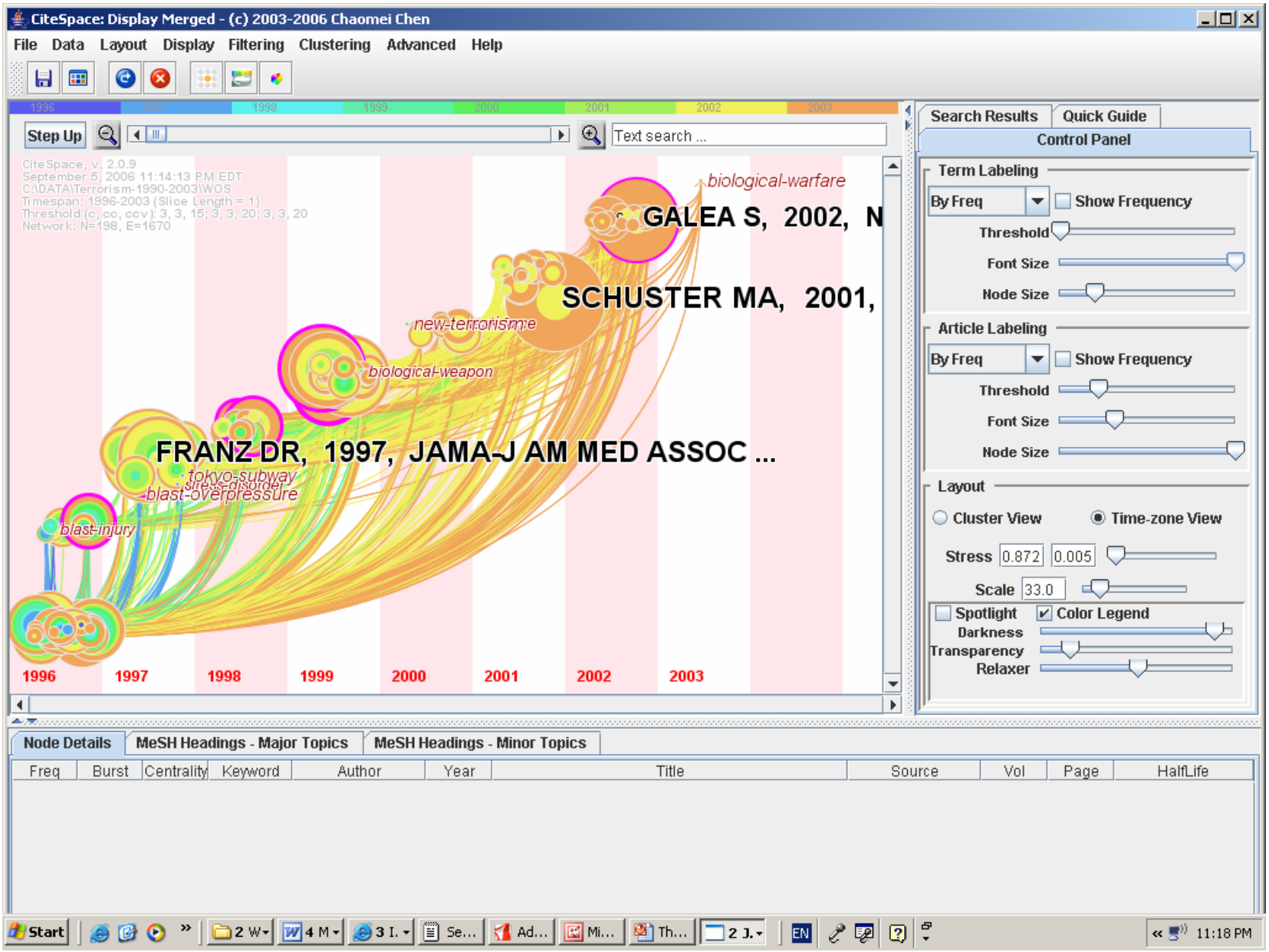
Excluded:
;
11 Explosions
7 Violence
4 Blast Injuries/*mortality

Cluster View



Timezone View



Users from 36 Countries Download 2+

(9/13/2004-8/23/2006)

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2	Spain	121	509	20	Mexico	3	10
3	Germany	35	101	21	Ireland	2	5
4	China	25	132	22	Israel	1	12
5	United Kingdom	16	64	23	Argentina	1	11
6	Taiwan	15	47	24	Kenya	1	7
7	Korea	12	40	25	Croatia	1	3
8	Canada	11	26	26	Finland	1	3
9	Denmark	10	62	27	India	1	3
10	The Netherlands	10	34	28	Puerto Rico	1	3
11	France	7	22	29	Slovenia	1	3
12	Japan	7	18	30	Belgium	1	2
13	Chile	6	21	31	Bulgaria	1	2
14	Russia	5	68	32	Egypt	1	2
15	Italy	4	23	33	Hong Kong	1	2
16	Brazil	4	16	34	Norway	1	2
17	Australia	4	14	35	Switzerland	1	2
18	Sweden	4	9	36	Thailand	1	2
					Subtotal (downloads >1)	**451**	**1,760**
					Grand Total	**1,247**	**2,619**

Users from 14 Countries WebStart It 30+

(9/13/2004-8/23/2006)

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5	Denmark	2	142
6	United Kingdom	2	124
7	Canada	3	114
8	Italy	2	78
9	Chile	1	60
10	Taiwan	1	41
11	Argentina	1	40
12	Mexico	1	39
13	The Netherlands	1	39
14	Korea	1	34
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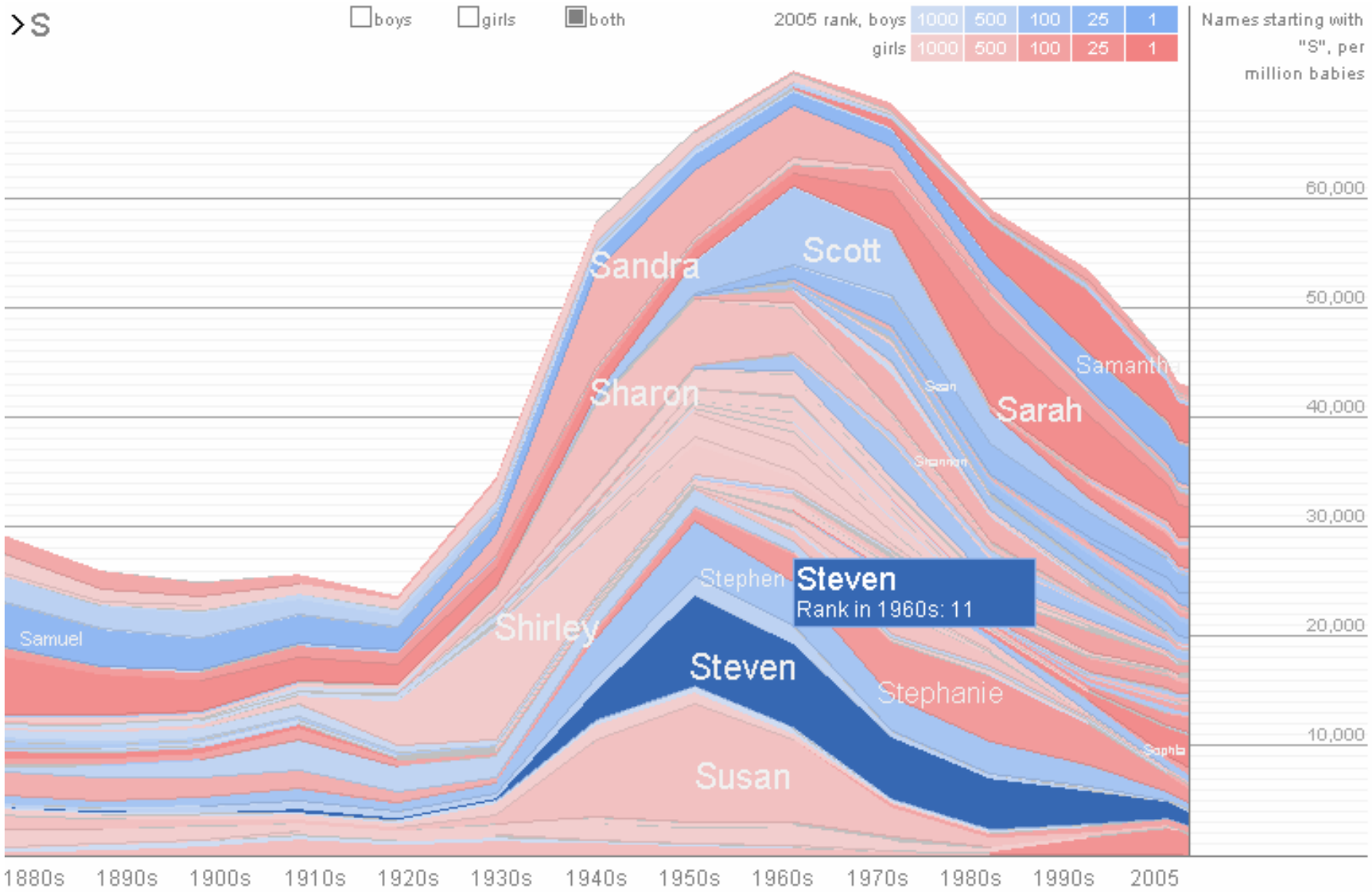
	Grand total	**1,546**	**9,833**

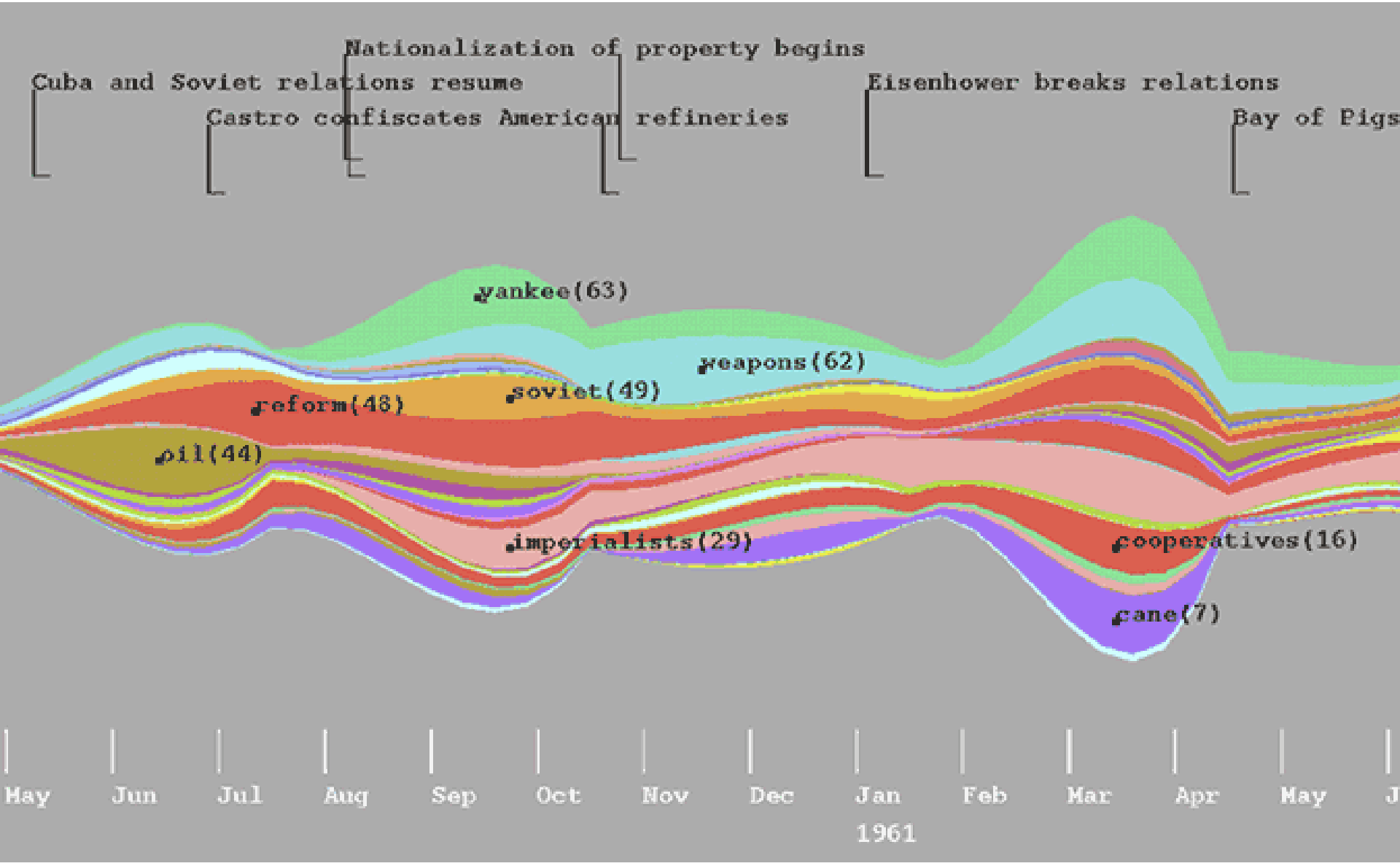
Timelines

NameVoyager



http://babynamewizard.com/namevoyager/lnv0105.html

ThemeRiver


Nationalization of property begins
Cuba and Soviet relations resume
Eisenhower breaks relations
Castro confiscates American refineries
Bay of Pigs
yankee(63)
weapons(62)
soviet(49)
reform(48)
oil(44)
imperialists(29)
cooperatives(16)
cane(7)
May
Jun
Jul
Aug
Sep
Oct
Nov
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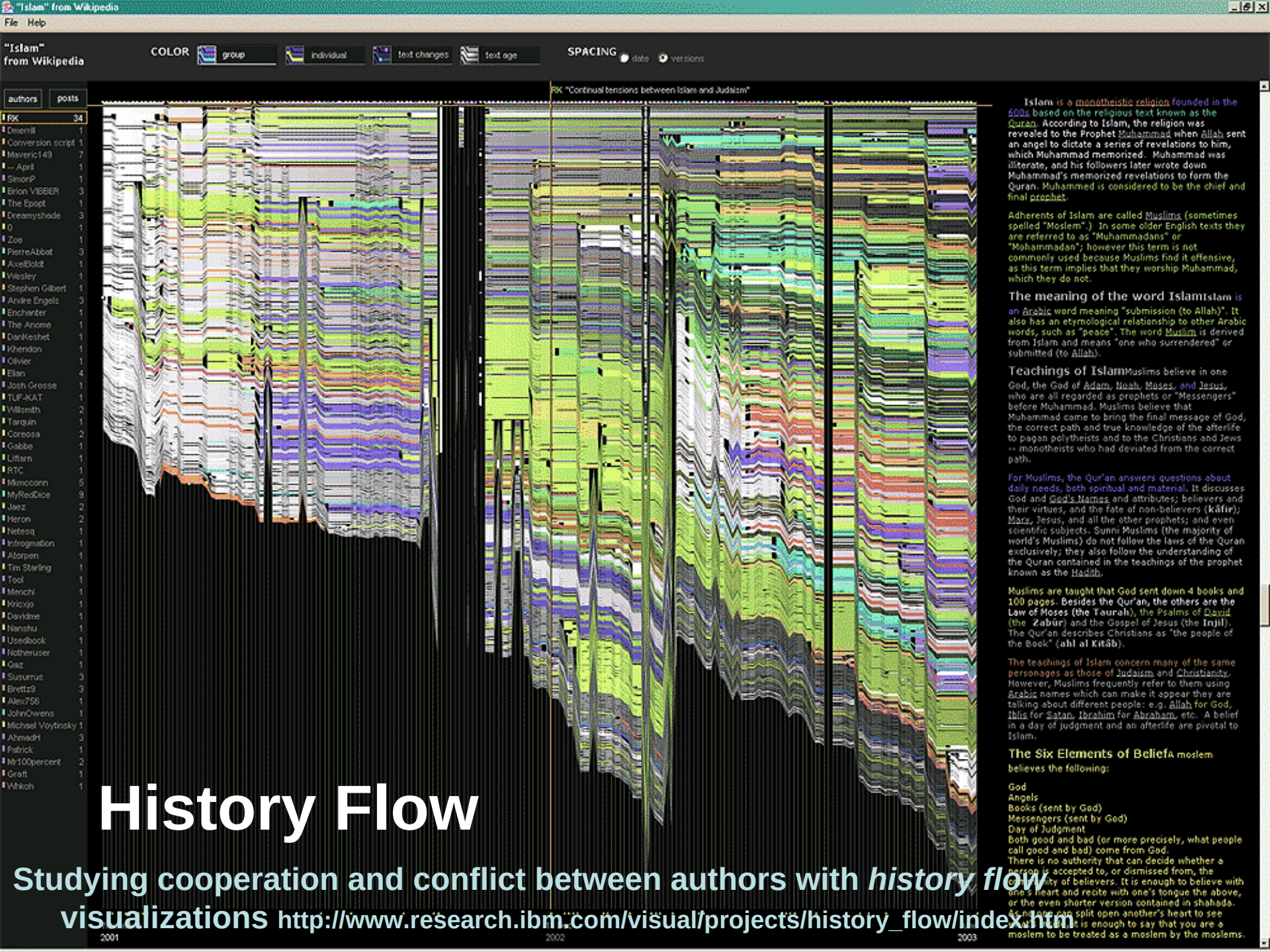
May
1961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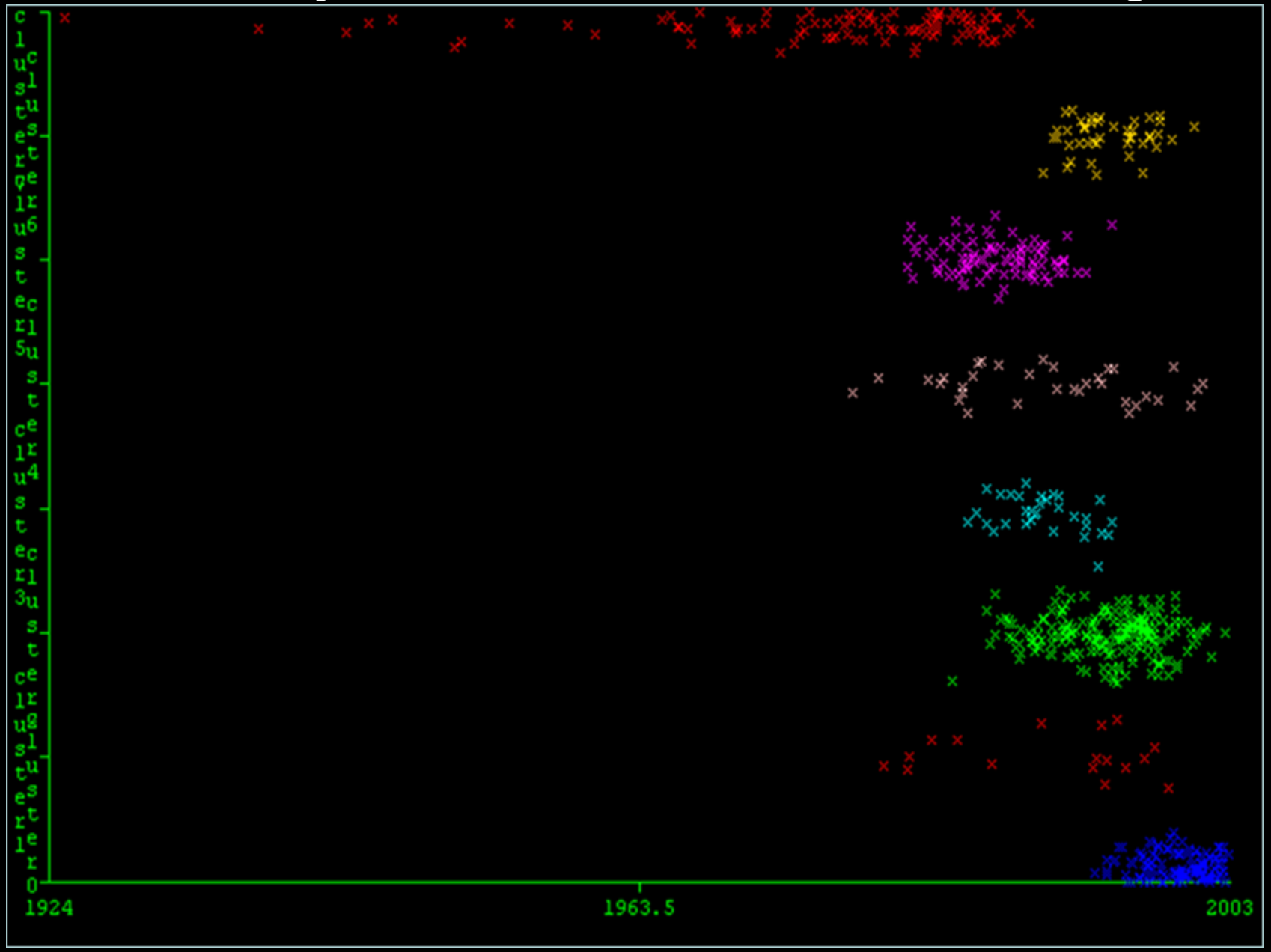
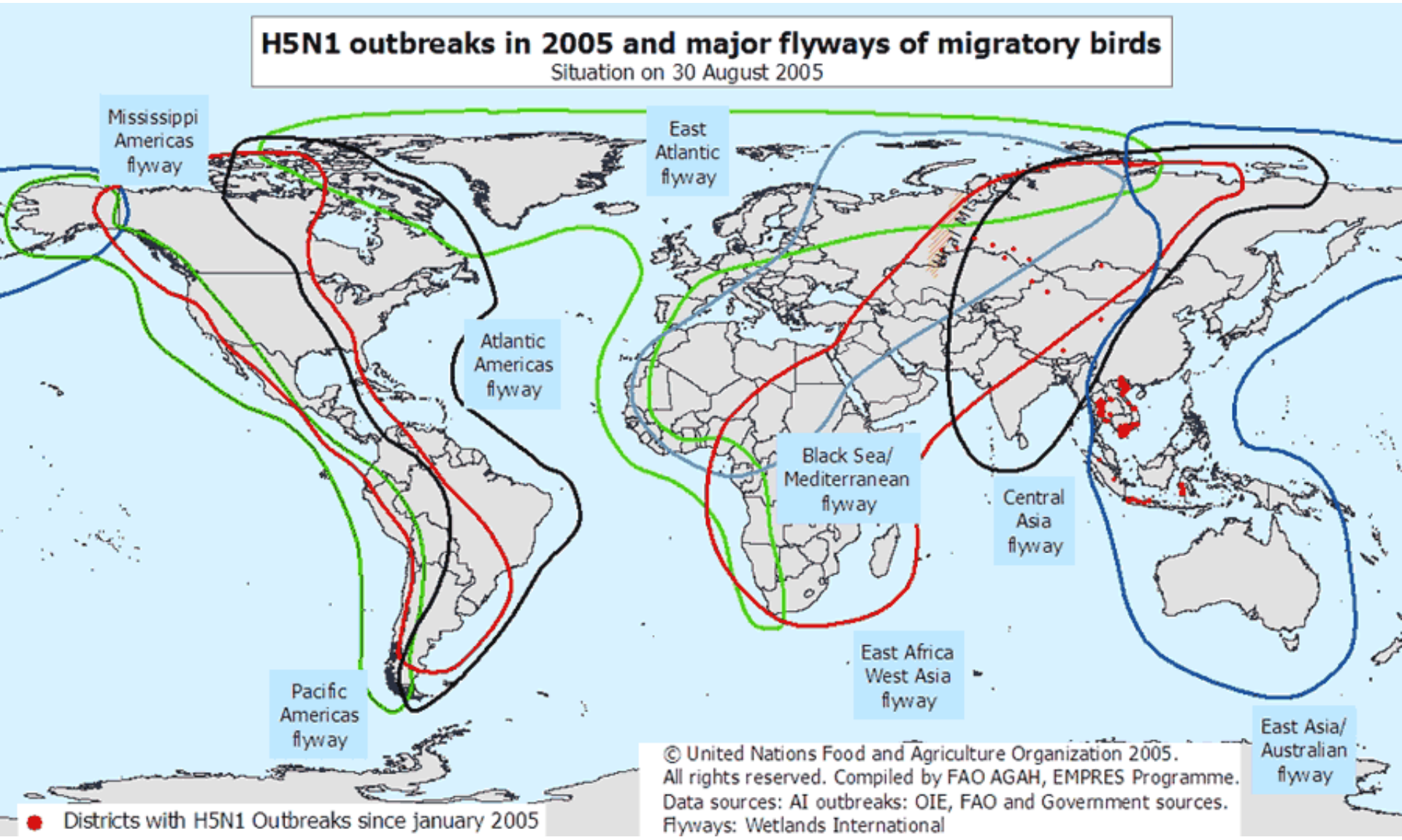
History Flow
Studying cooperation and conflict between authors with history flow visualizations
http://www.research.ibm.com/visual/projects/history_flow/index.htm

The Dynamics of Scientific Knowledge



Spatial and Conceptual Diffusion



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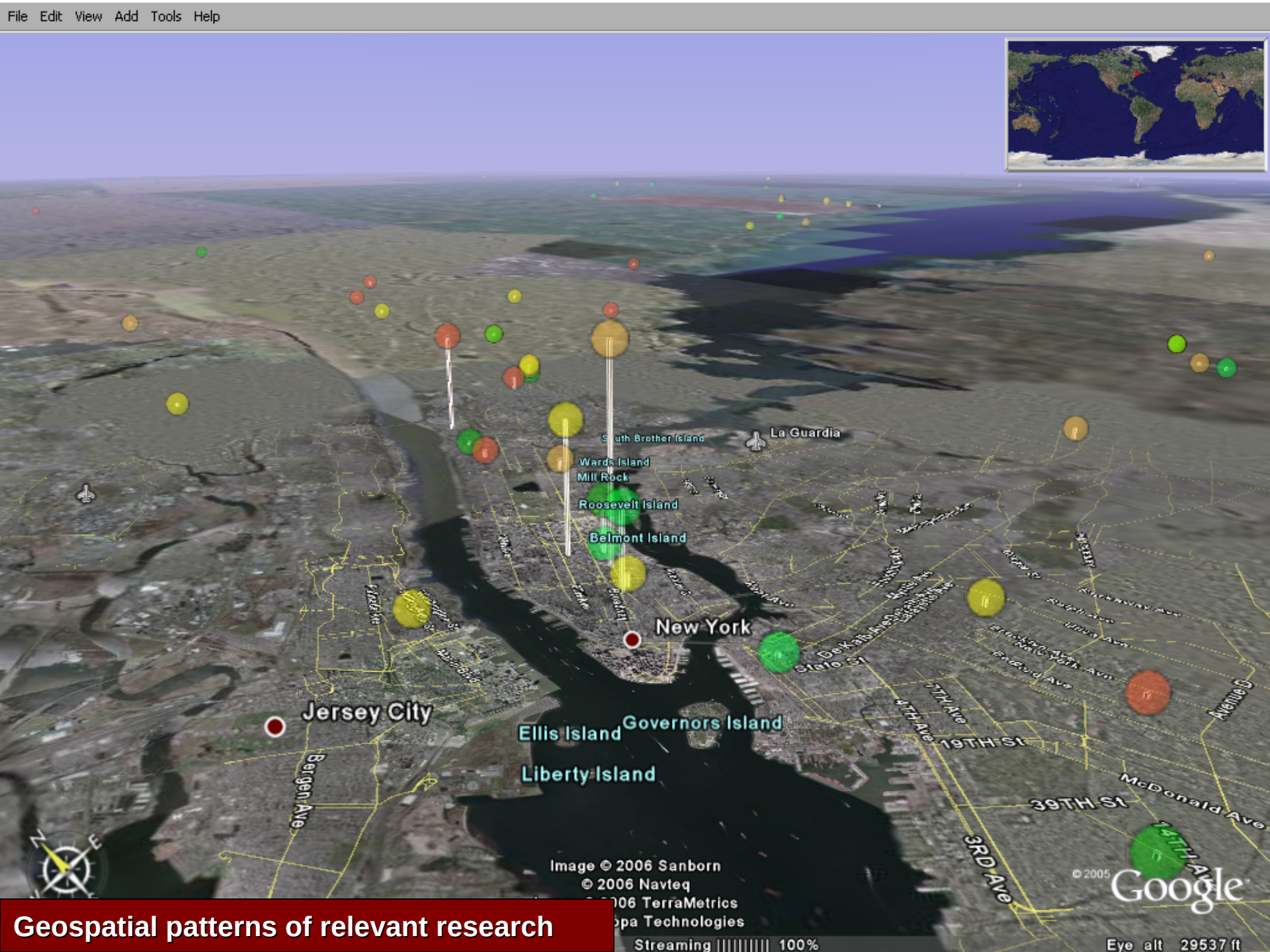
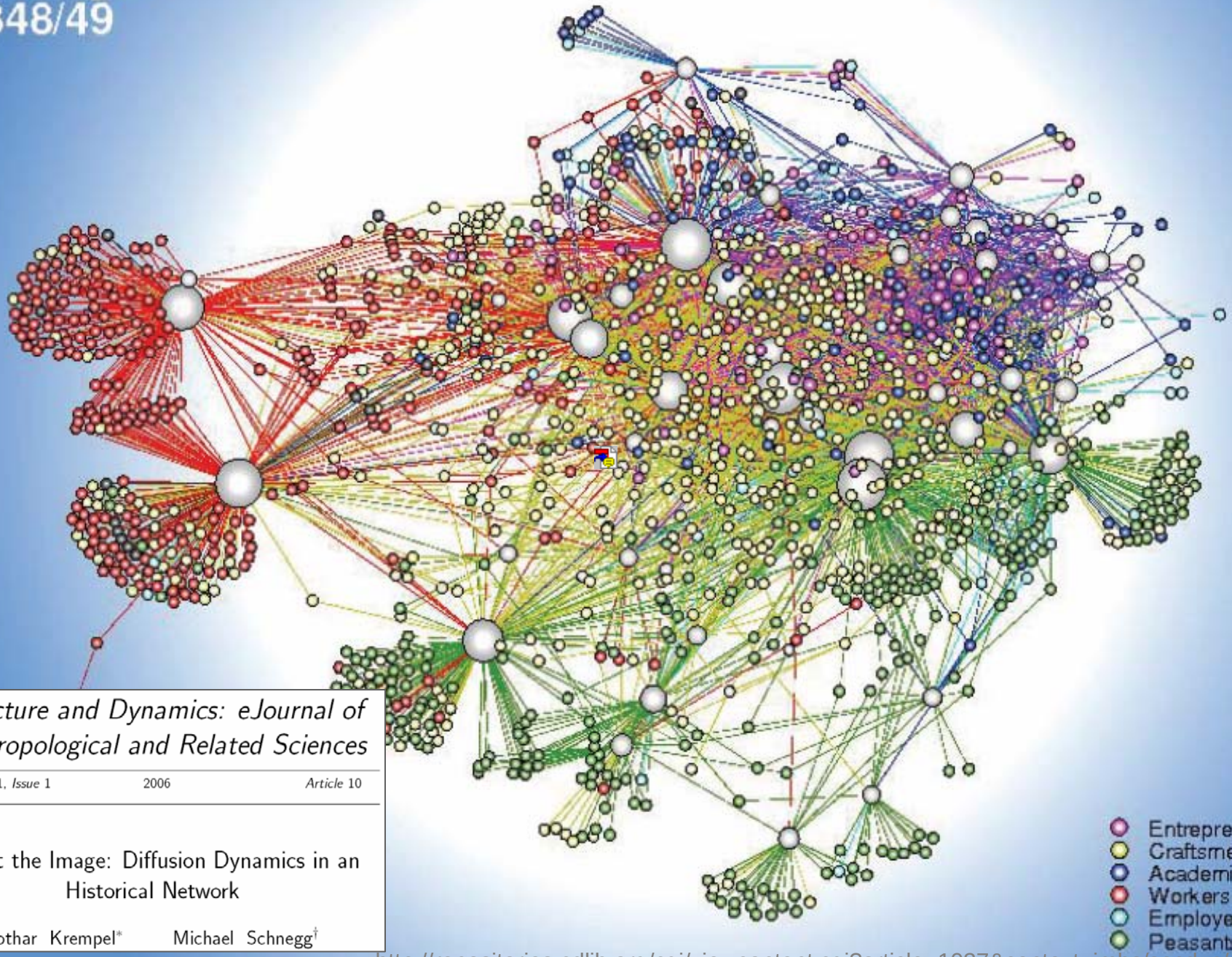
Geospatial patterns of terrorist events



Geospatial patterns of relevant research

Esslingen 1848/49



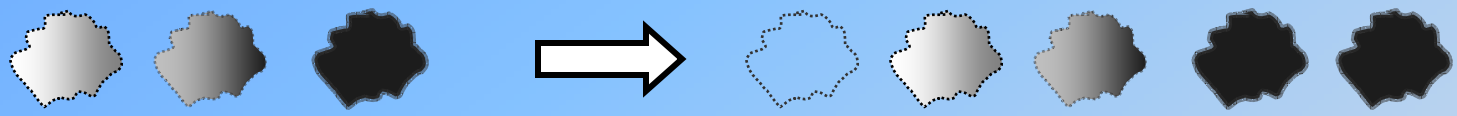
Structure and Dynamics: eJournal of Anthropological and Related Sciences

Volume 1, *Issue* 1 2006 *Article* 10

About the Image: Diffusion Dynamics in an Historical Network

Lothar Krempel* Michael Schnegg†

The Role of Turning Points in Evolution and … Diffusion



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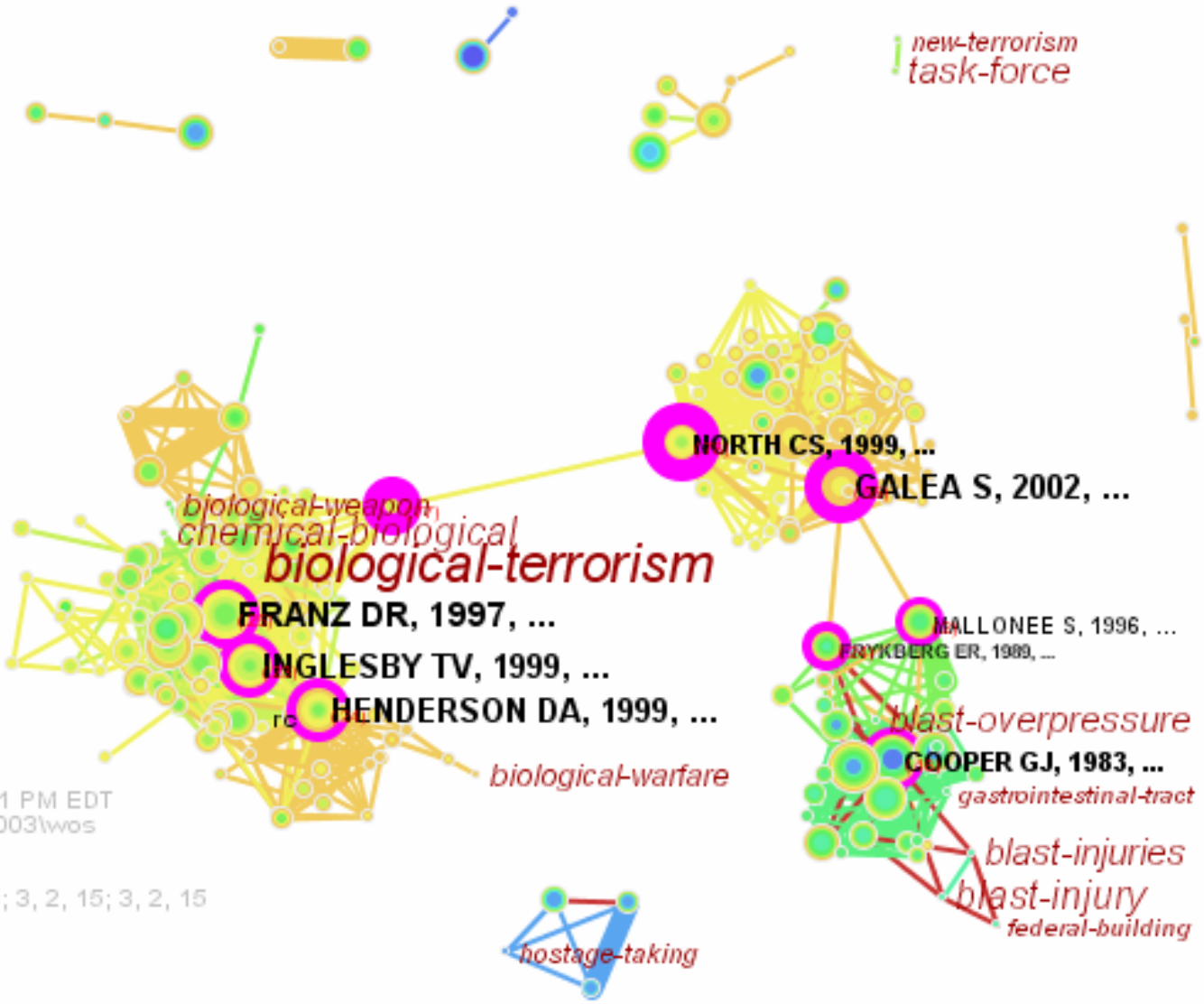

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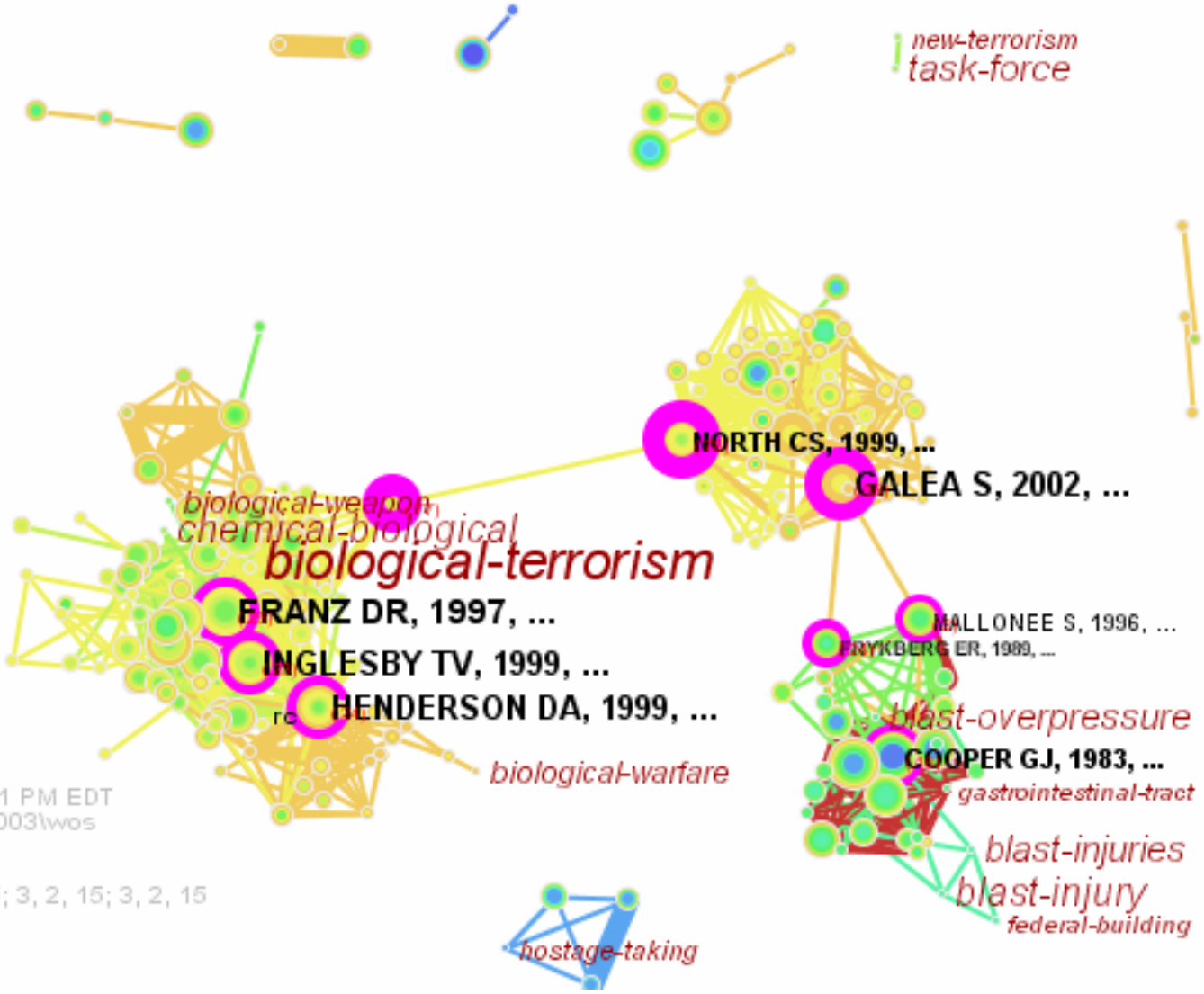

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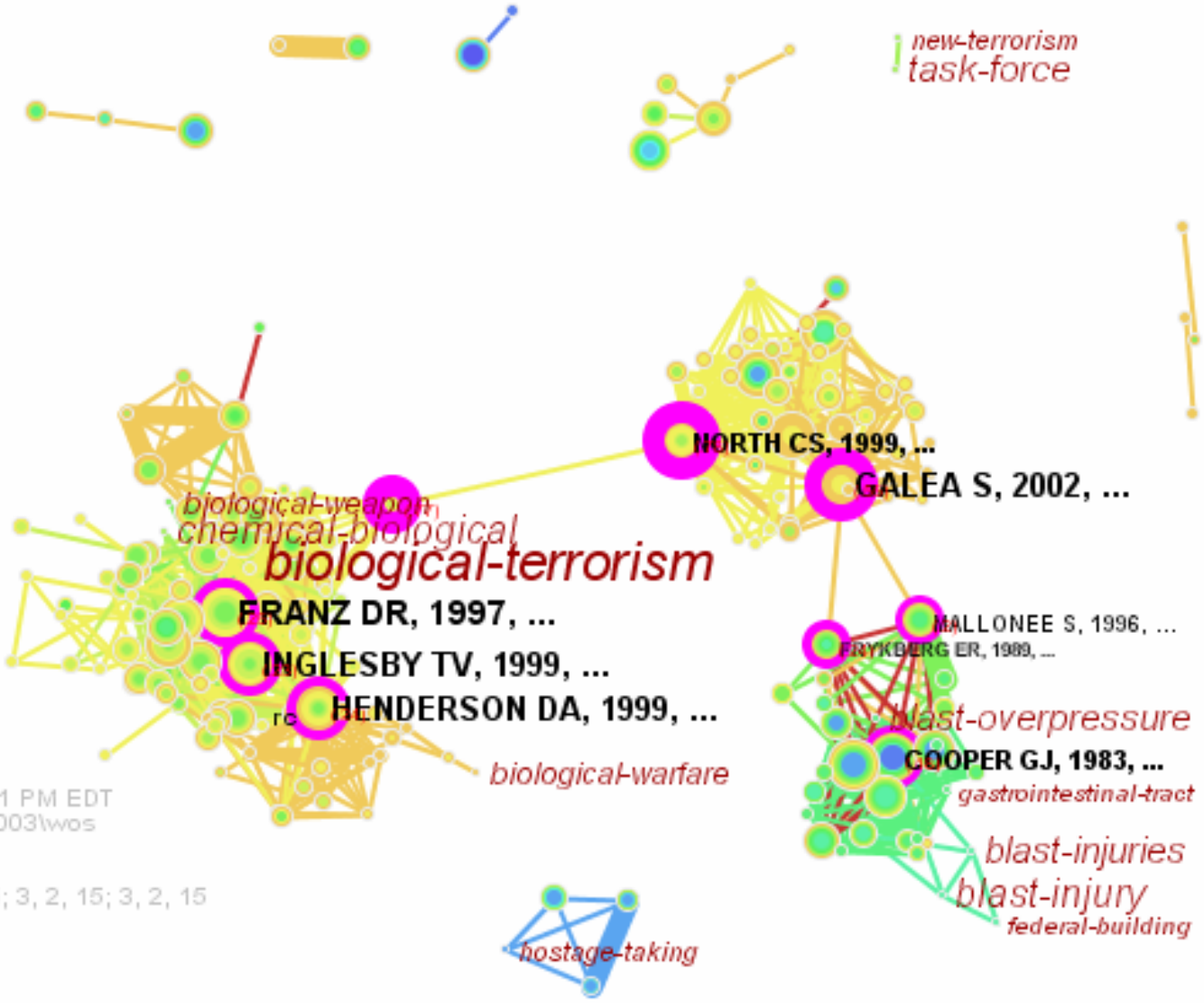
1998-1998



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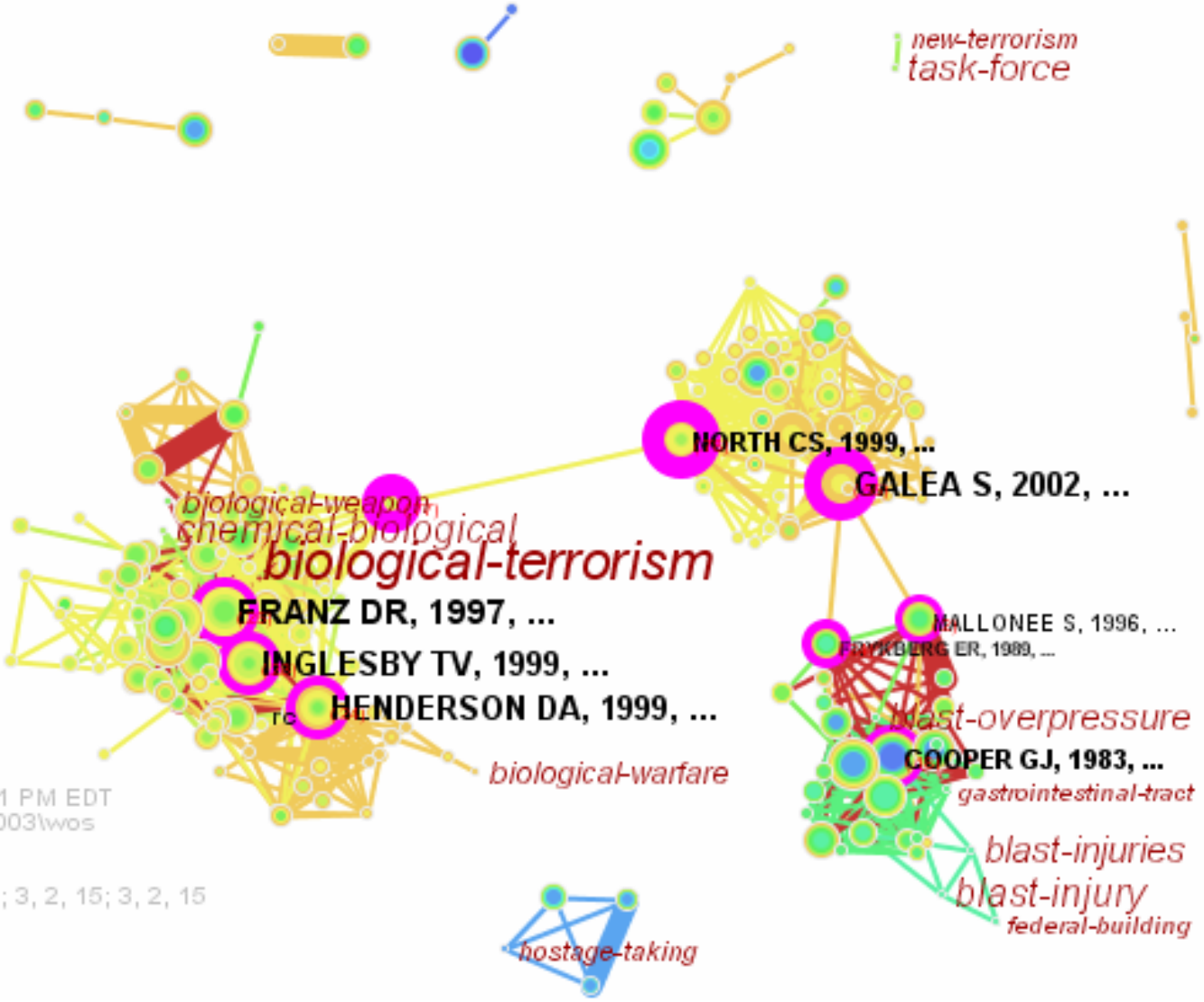
1999-1999



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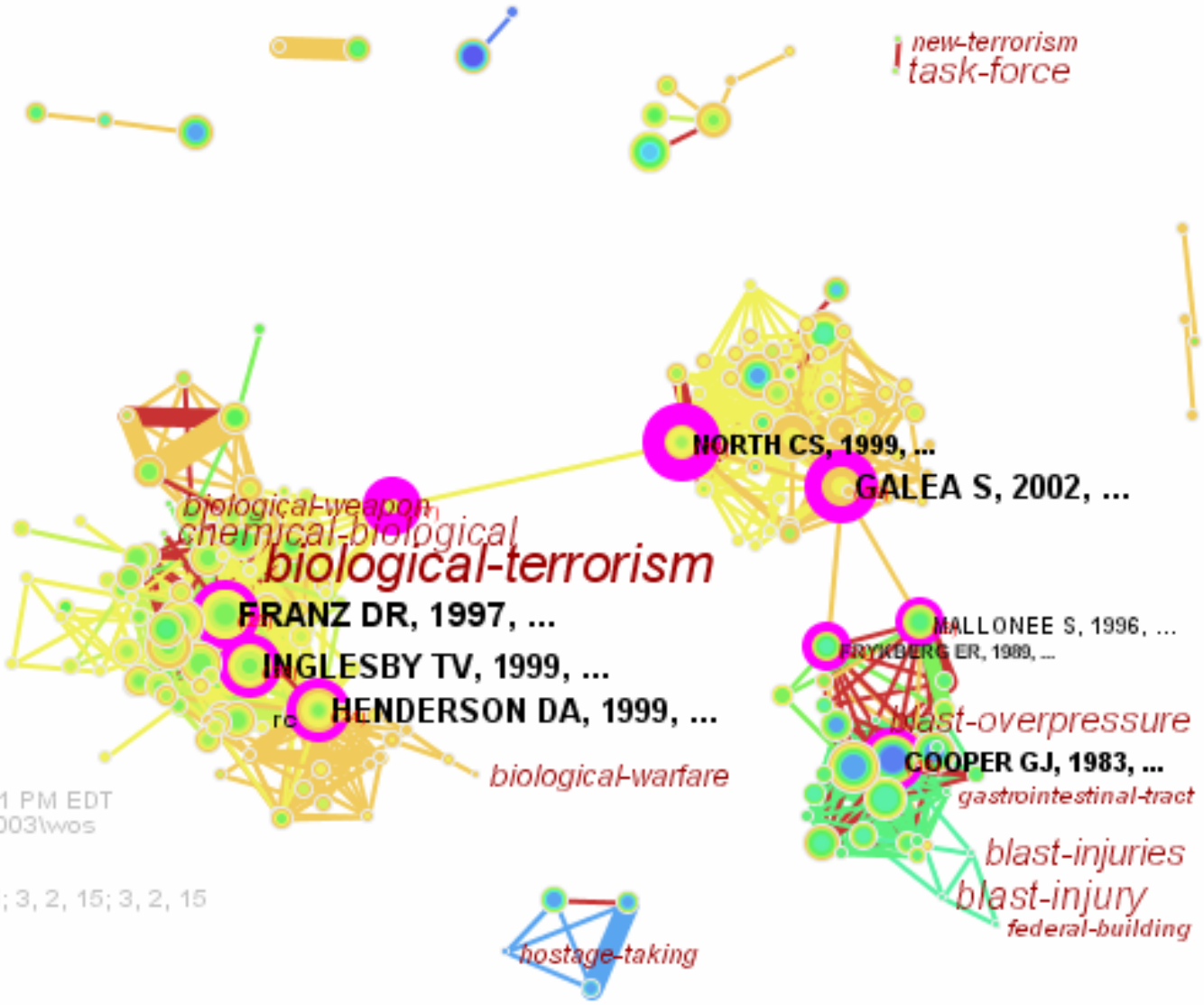
2000-2000



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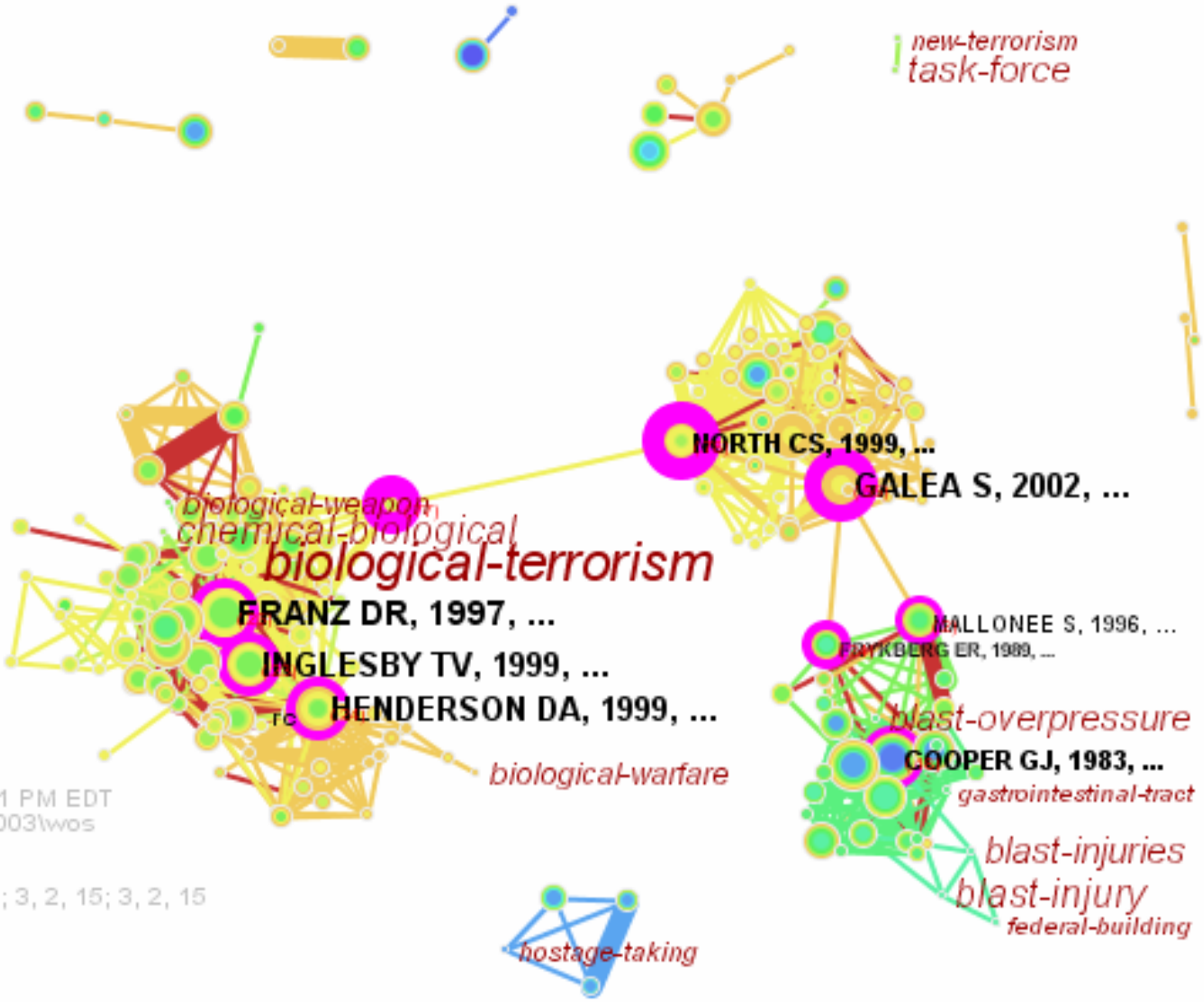
2001-2001



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Network: N=192, E=873
Excluded:
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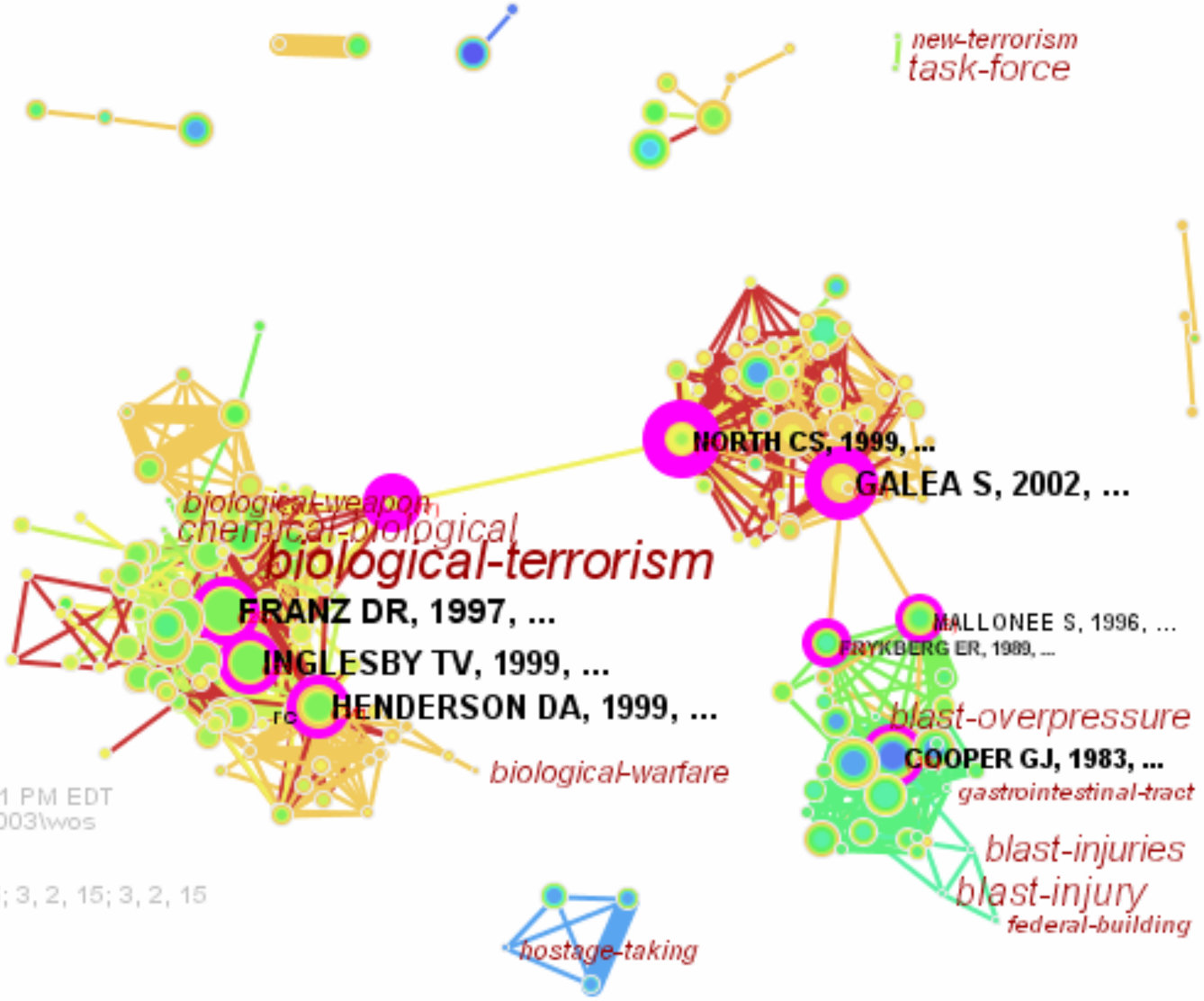
2002-2002



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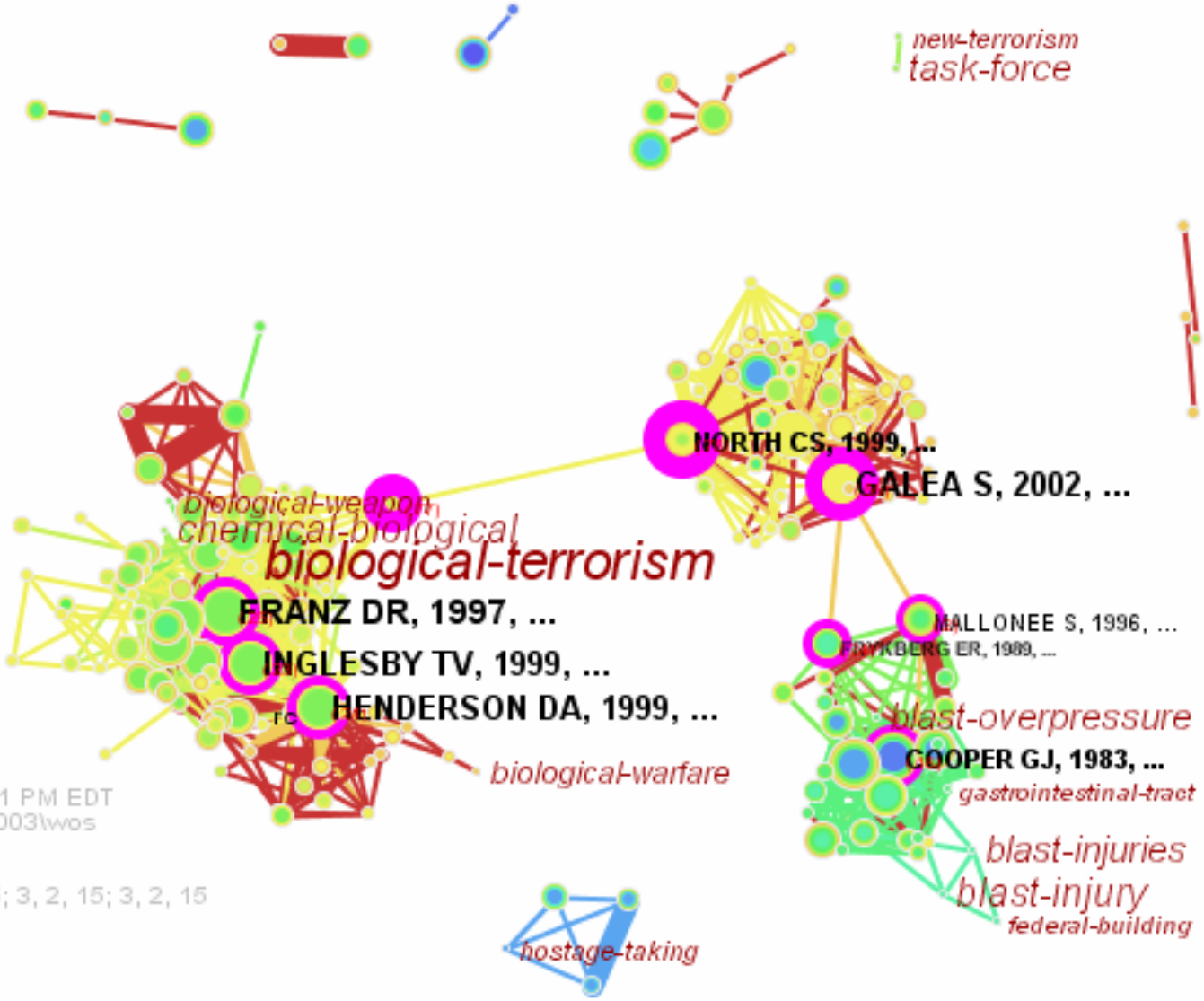
2003-2003



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The Impact of a Pivotal Point

Galea, S. et al. (2002)

How does the citations to this paper spread geographically?

http://cluster.cis.drexel.edu/~cchen/talks/inscit2006/GLEA_M.kml

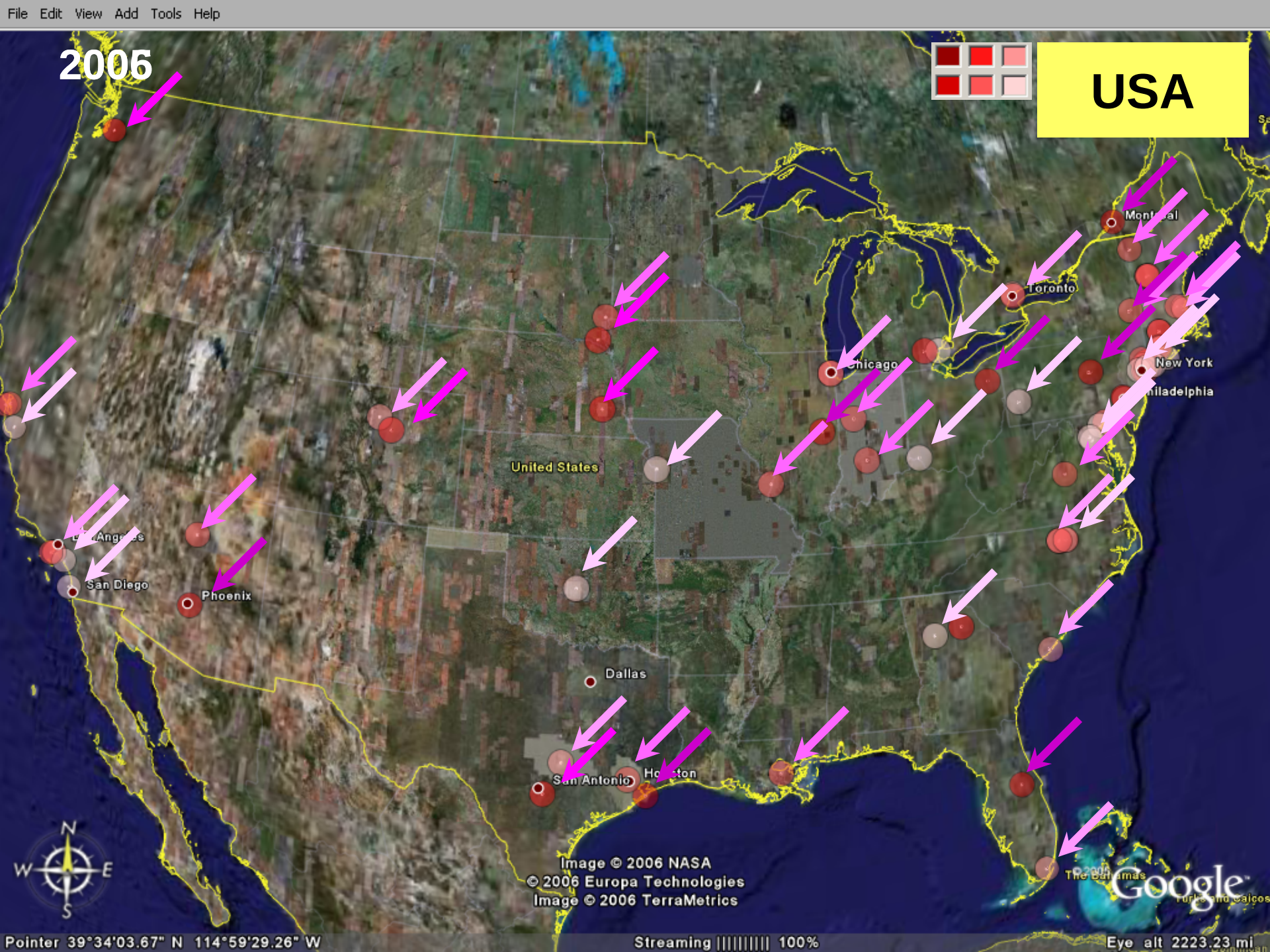
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Image © 2006 NASA
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Google
Pointer 39°34'03.67" N 114°59'29.26" W
Streaming 100%
Eye alt 2223.23 mi


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Citers to Galea et al. (2002)
Pennsylvania
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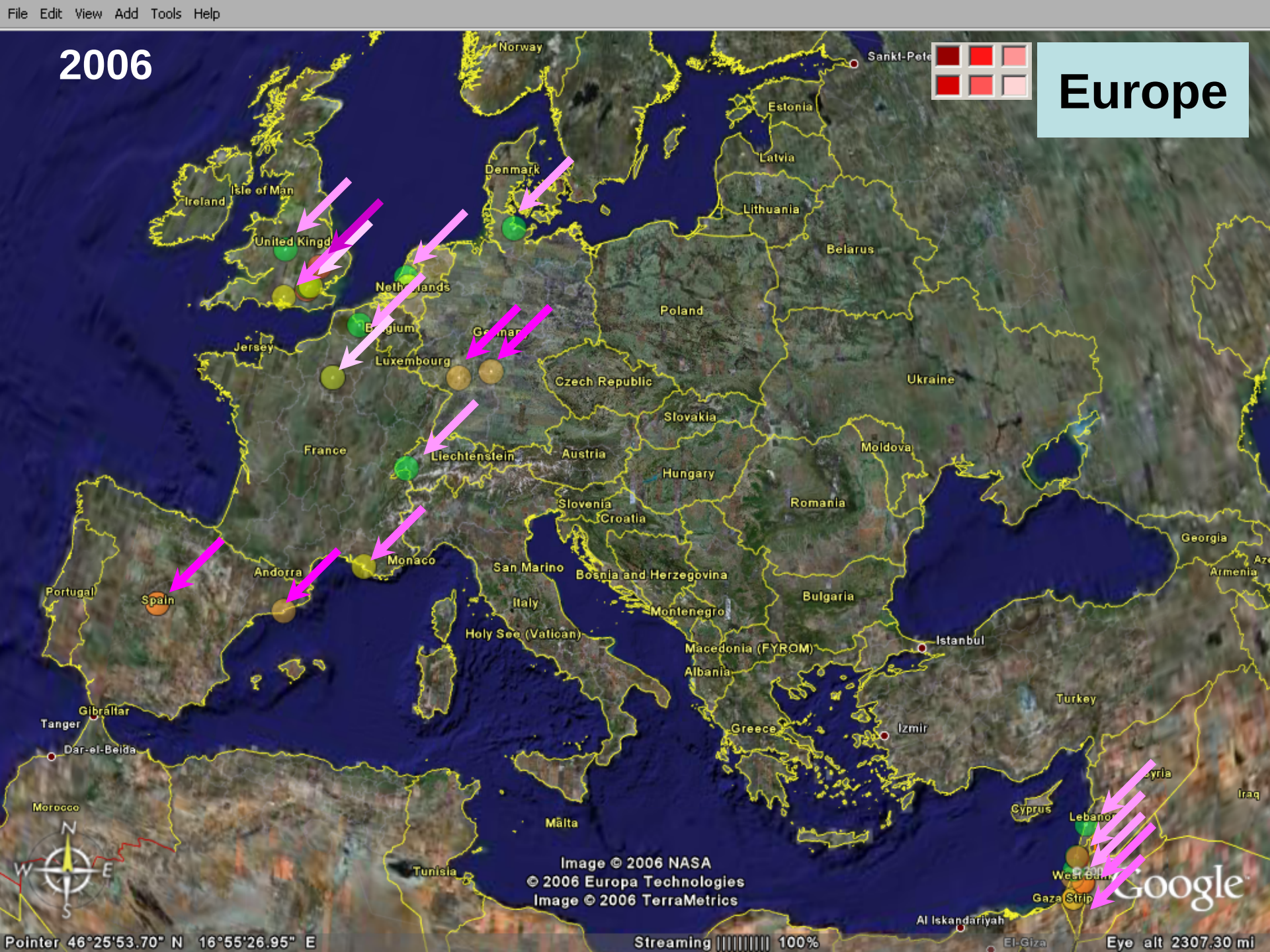
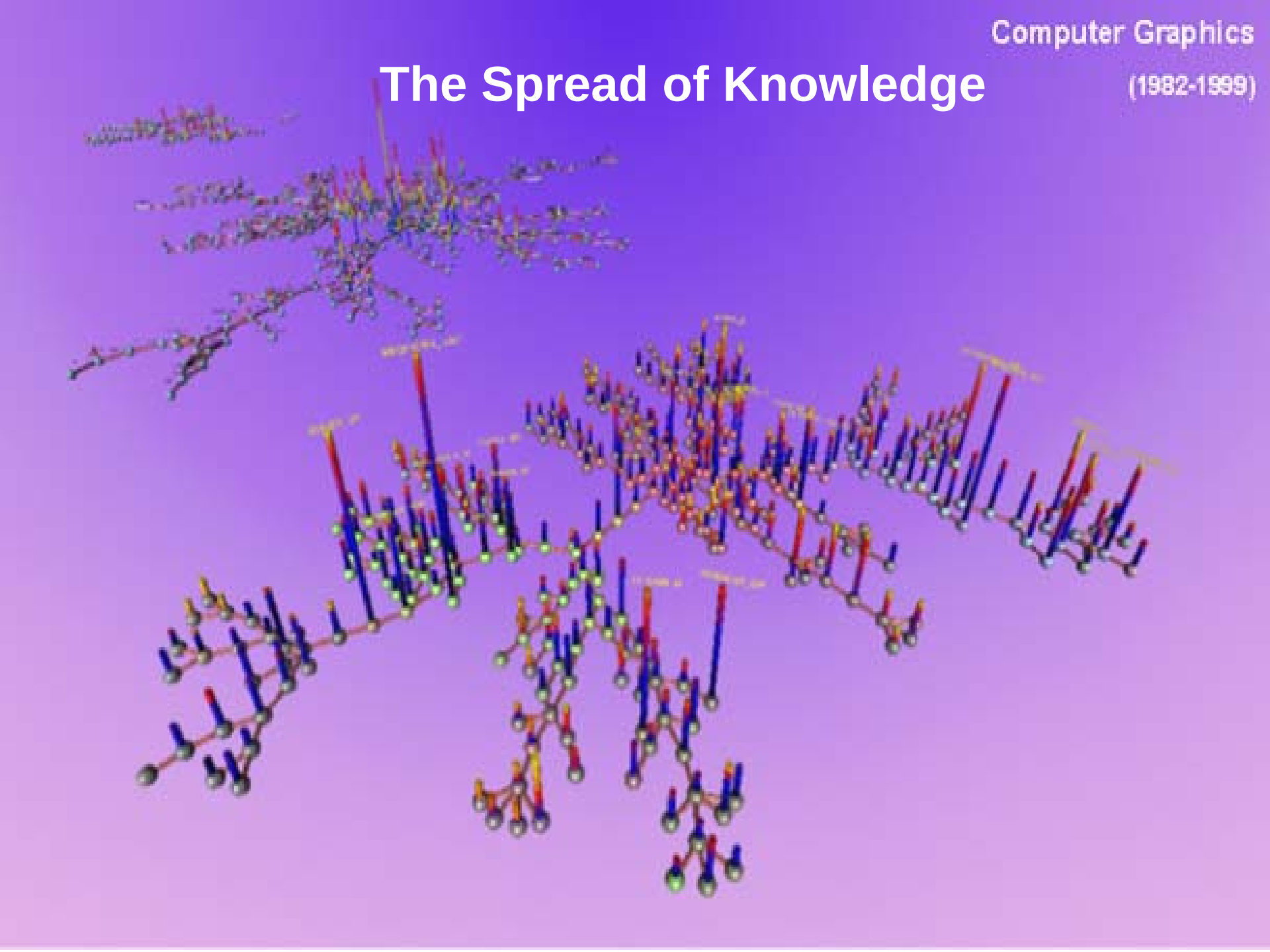
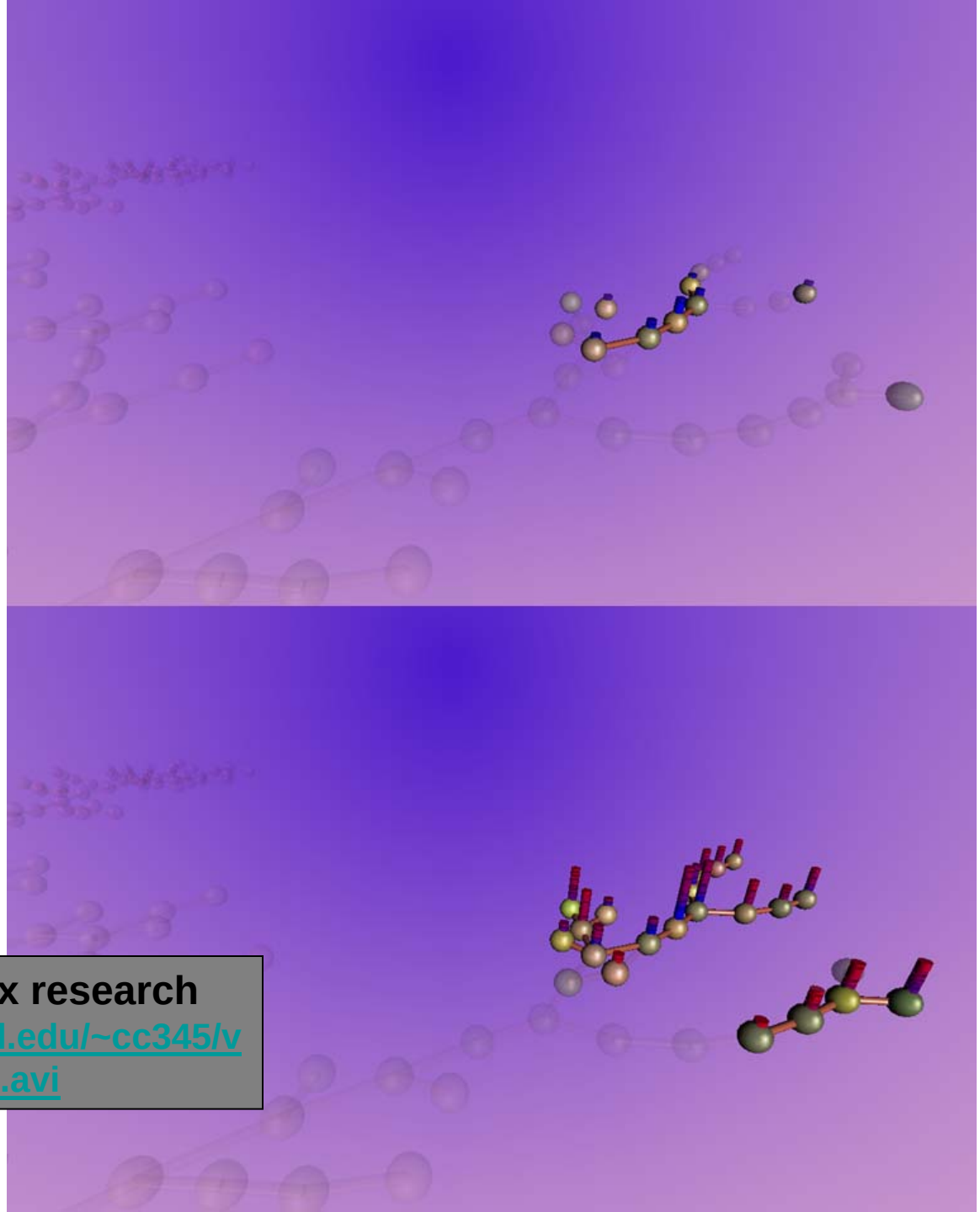


The Spread of Knowledge

The Spread of Knowledge





An animation of botox research
http://www.pages.drexel.edu/~cc345/video/citation_land_local.avi

What influences the diffusion process?

Making Sense of Emergent Social Phenomena

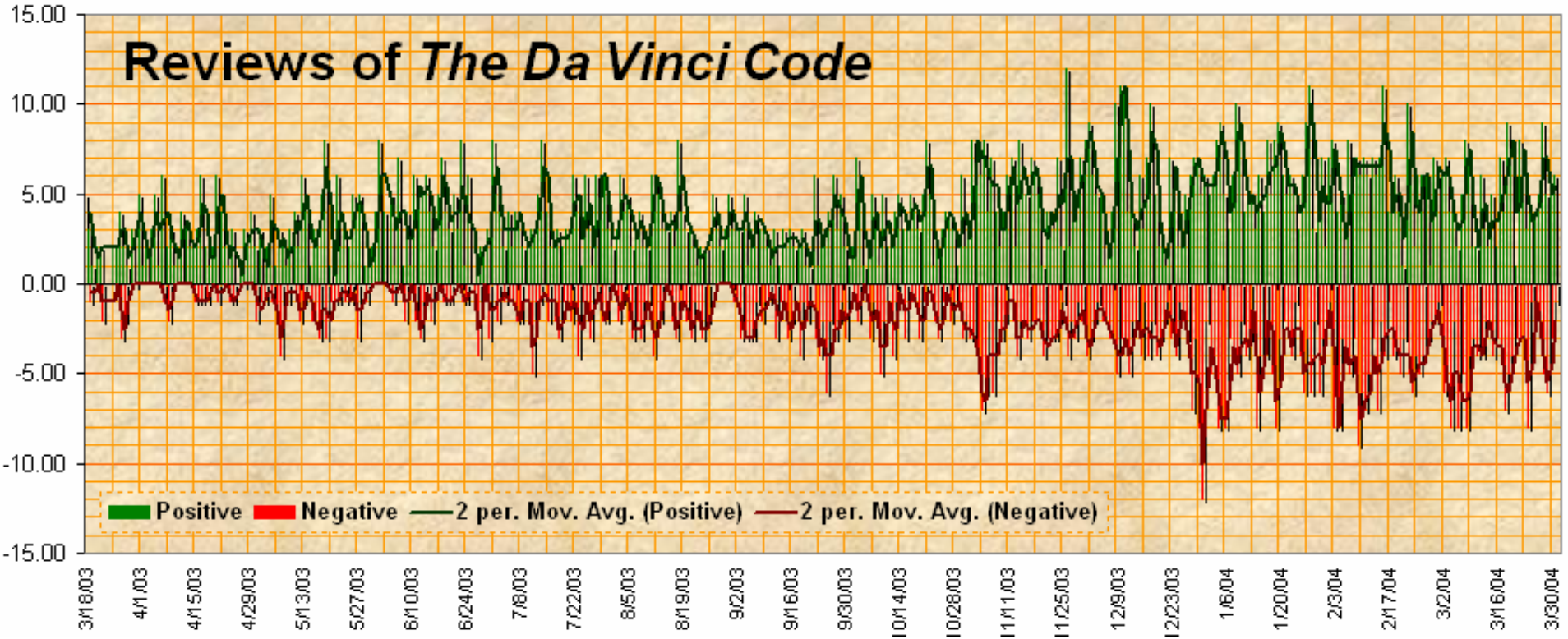
- Amazon
- Blogmarks
- CiteULike
- Del.ici.us
- …
- Wikepedia

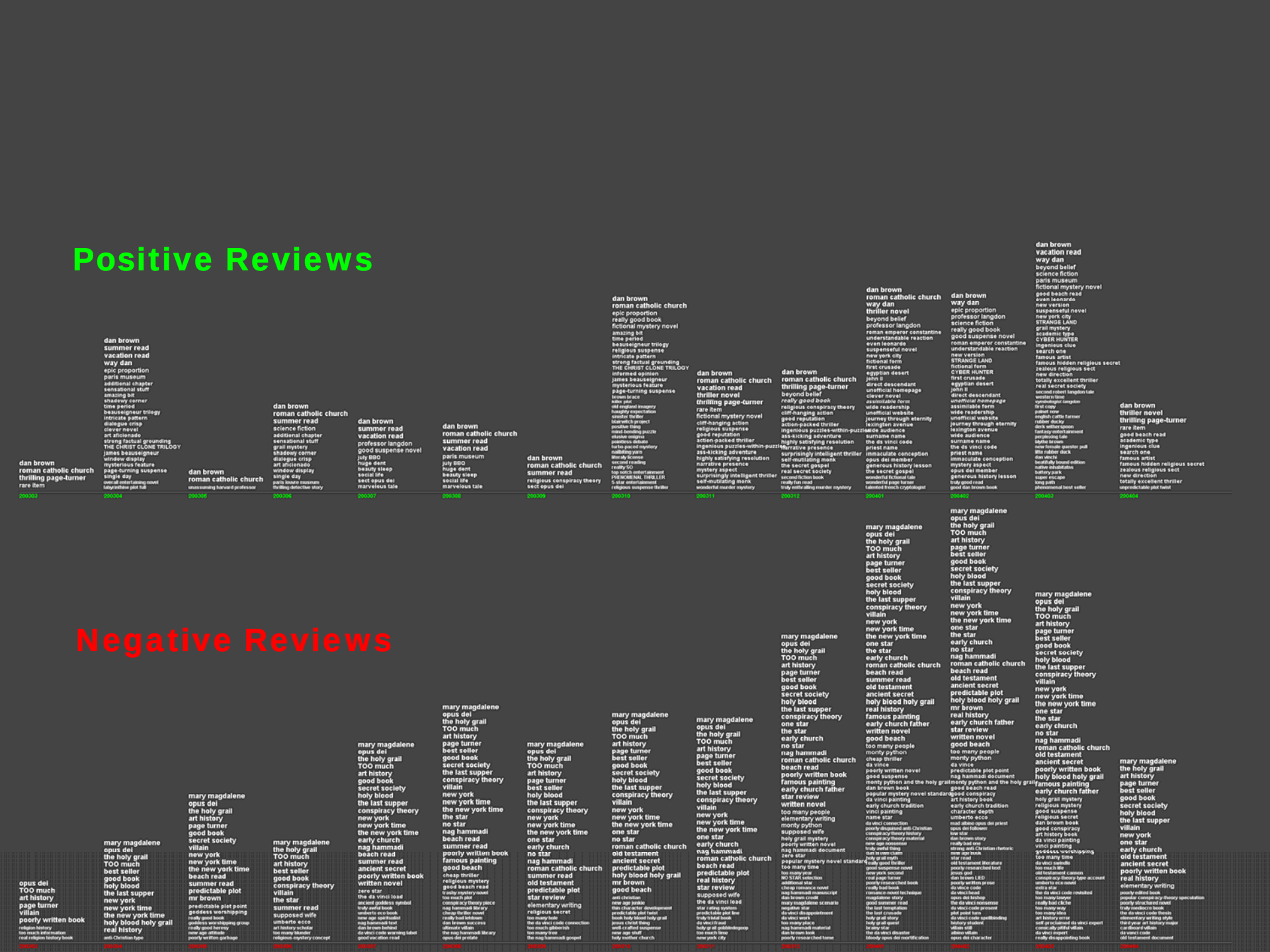
- Emotional and Sentimental Analysis
- Information Diffusion Through Blogspace

Differentiating Conflicting Views

1,738 positive reviews (=4, 5)

918 negative reviews (=1, 2)

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roman catholic church
thrilling page-turner
rare item
290302
dan brown
summer read
vacation read
way dan
epic proportion
paris museum
additional chapter
sensational stuff
amazing bit
shadowy corner
time period
beauseigneur trilogy
intricate pattern
strong factual grounding
THE CHRIST CLONE TRILOGY
james beauseigneur
window display
mysterious feature
page-turning suspense
single day
overall entertaining novel
labyrinthine plot full
290304
dan brown
roman catholic church
unassuming harvard professor
290305
dan brown
roman catholic church
summer read
science fiction
additional chapter
sensational stuff
grail mystery
shadowy corner
dialogue crisp
art aficionado
window display
single day
paris louvre museum
thrilling detective story
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vacation read
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huge dent
beauty sleep
social life
sect opus dei
marvelous tale
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summer read
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paris museum
july BBQ
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marvelous tale
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roman catholic church
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really good book
fictional mystery novel
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THE CHRIST CLONE TRILOGY
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old england imagery
haughty expectation
sinister thriller
blah witch project
positive thing
mind bending puzzle
elusive enigma
pointless debate
turbo paced mystery
nailbiting yarn
literally license
second reading
reality SO
top notch entertainment
PSYCHOBABBAL THRILLER
5-star entertainment
religious suspense thriller
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religious suspense
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ass-kicking adventure
highly satisfying resolution
narrative presence
mystery aspect
surprisingly intelligent thriller
self-mutilating monk
wonderful murder mystery
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thrilling page-turner
beyond belief
really good book
religious conspiracy theory
cliff-hanging action
good reputation
action-packed thriller
ingenious puzzles-within-puzzles
ass-kicking adventure
highly satisfying resolution
narrative presence
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self-mutilating monk
the secret gospel
real secret society
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really fun read
truly enthralling murder mystery
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way dan
thriller novel
beyond belief
professor langdon
roman emperor constantine
understandable reaction
even leonardo
suspenseful novel
new york city
fictional form
first crusade
egyptian desert
john II
direct descendant
unofficial homepage
clever novel
assimilable form
wide readership
unofficial website
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lexington avenue
wide audience
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priest name
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CYBER HUNTER
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dirk wilter spoon
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little rubber duck
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da vinci expert
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new york
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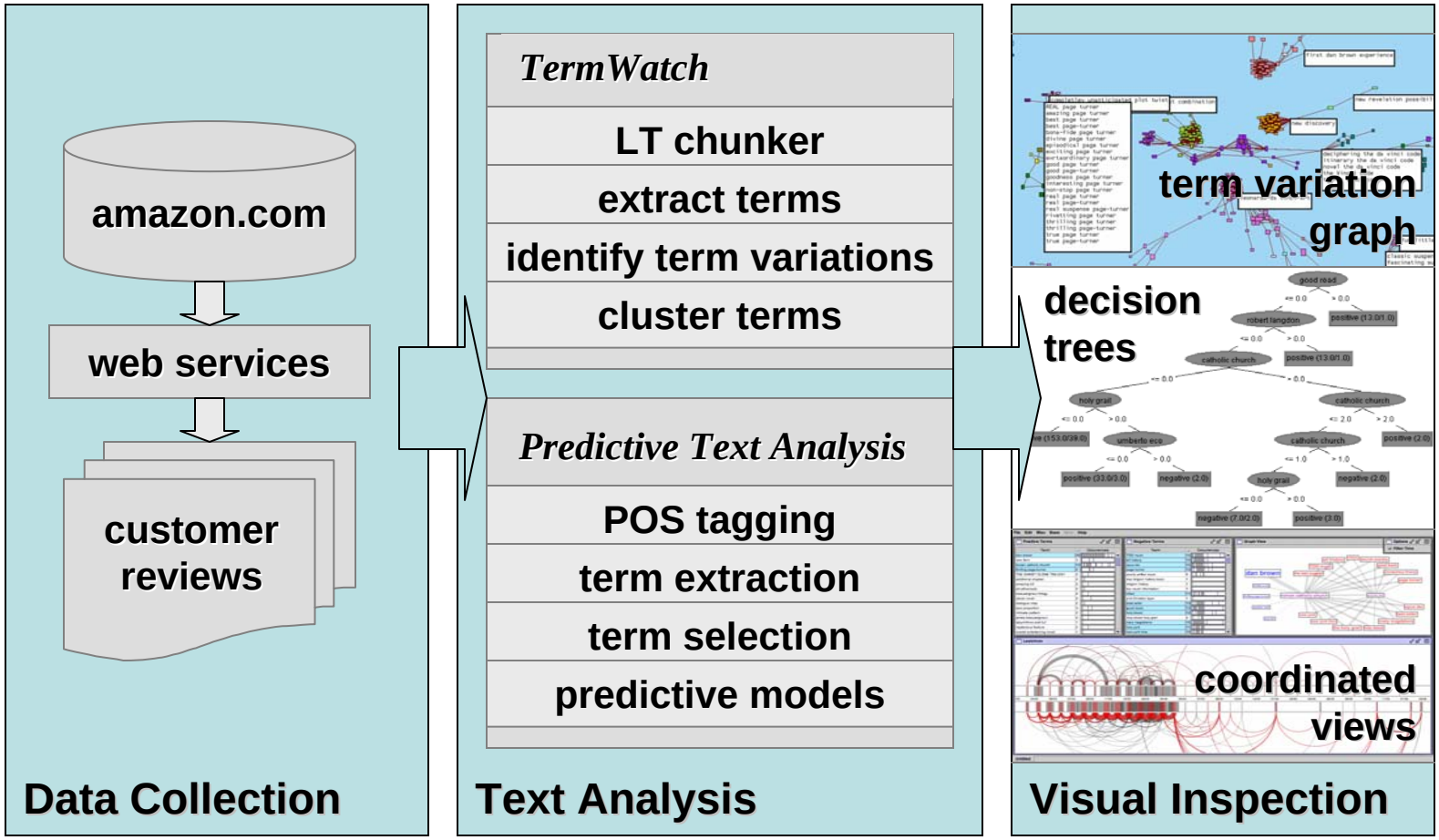
amazon.com
web services
customer reviews
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extract terms
identify term variations
cluster terms
Predictive Text Analysis
POS tagging
term extraction
term selection
predictive models
Text Analysis
term variation graph
decision trees
coordinated views
Visual Inspection

Term Variations

- Head substitution

  age-old religious **secret** ➔ age-old religious **mystery**

- Expansion

  action thriller ➔ **perfect suspense** action thriller

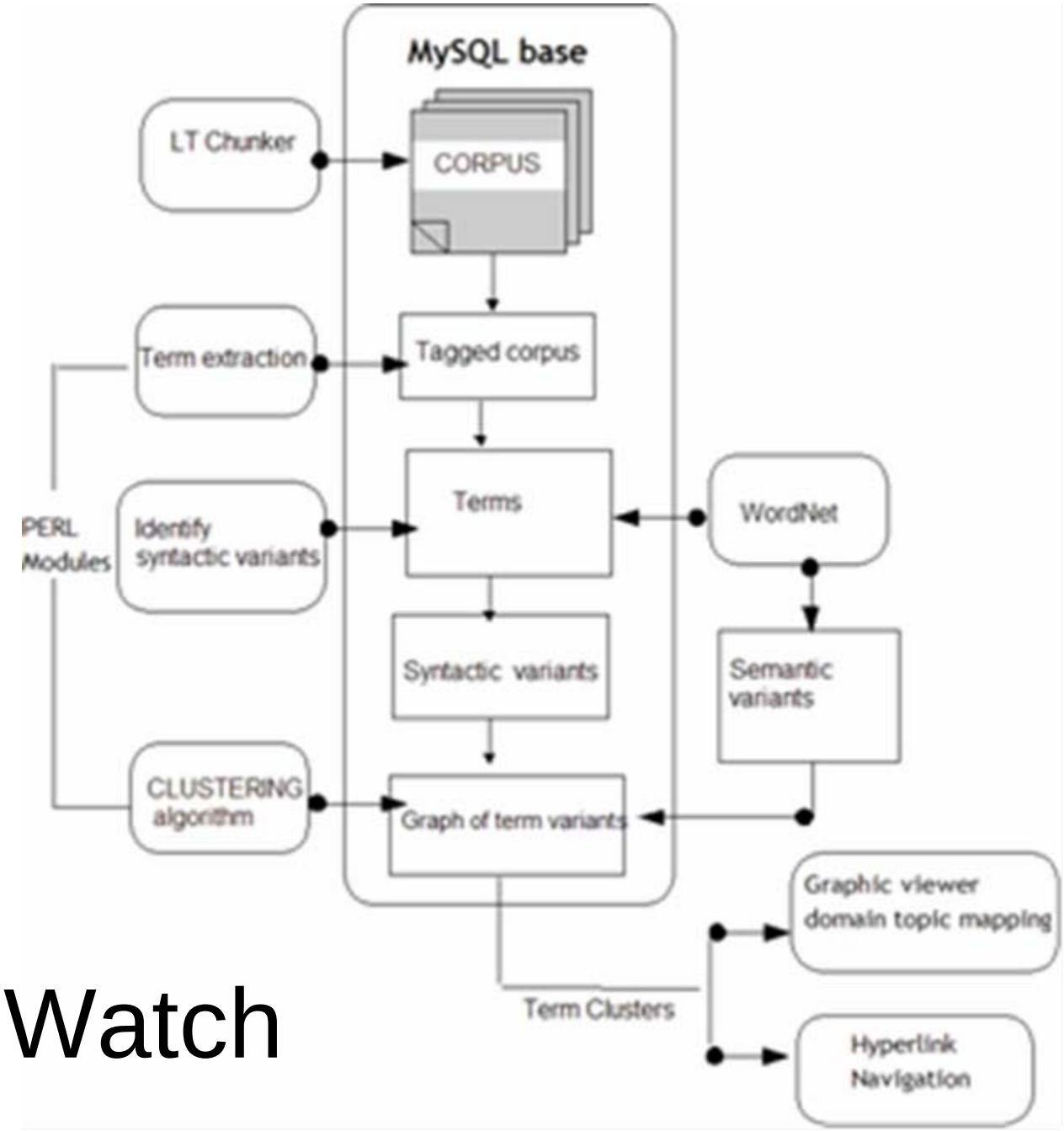
  amusing speculation ➔ amusing speculation **collection**

  roller coaster ➔ **electrifying** roller coaster **ride**

- Association

  mind-binding puzzle ➔➔ 5-star entertainment

TermWatch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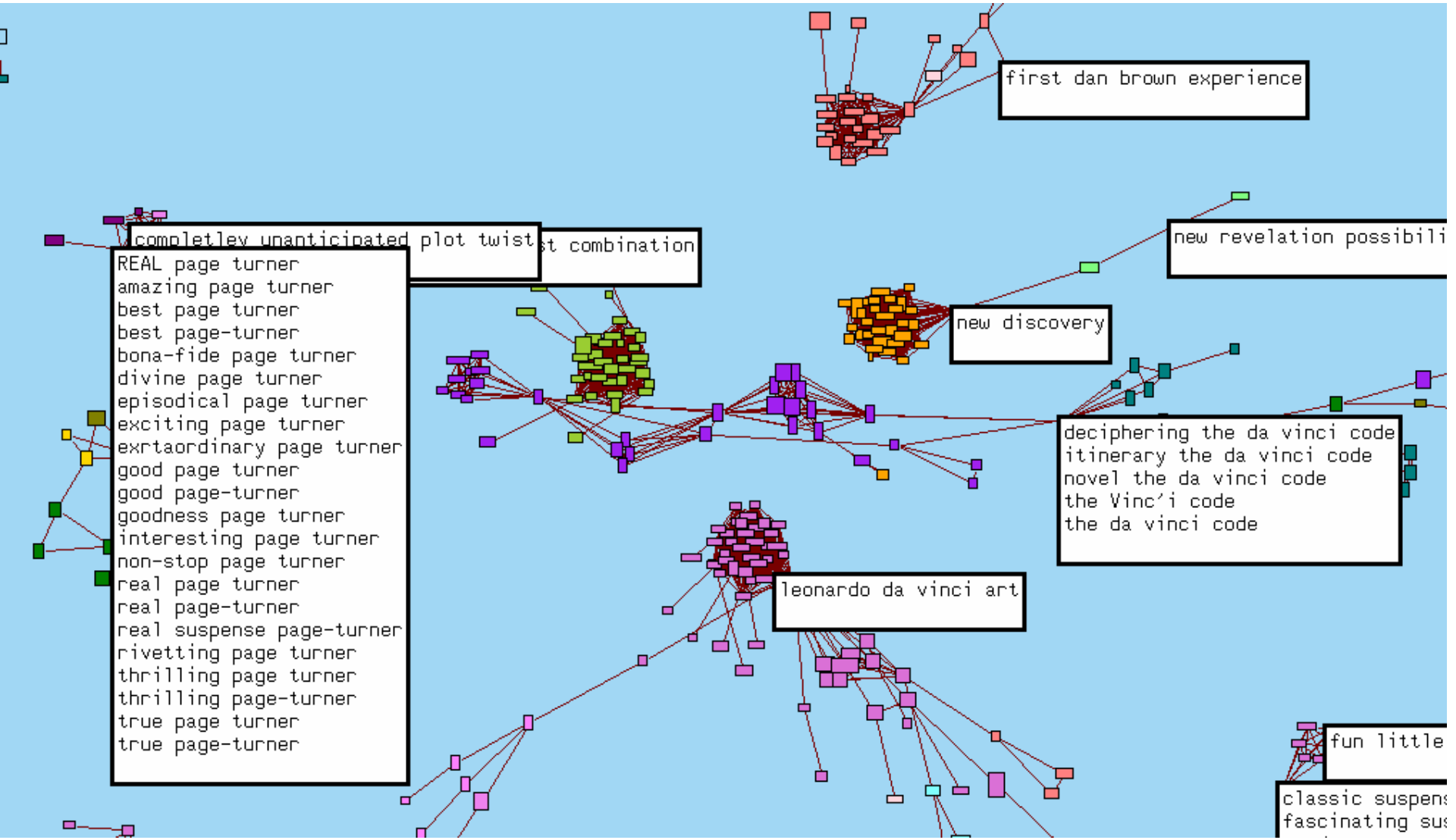
CORPUS
Term extraction
Tagged corpus
PERL
Modules
Identify
syntactic variants
Terms
WordNet
Syntactic variants
Semantic
variants
CLUSTERING
algorithm
Graph of term variants
Graphic viewer
domain topic mapping
Term Clusters
Hyperlink
Navigation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best page turner
best page-turner
bona-fide page turner
divine page turner
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exrtaordinary page turner
good page turner
good page-turner
goodness page turner
interesting page turner
non-stop page turner
real page turner
real page-turner
real suspense page-turner
rivetting page turner
thrilling page turner
thrilling page-turner
true page turner
true page-turner
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itinerary the da vinci code
novel the da vinci code
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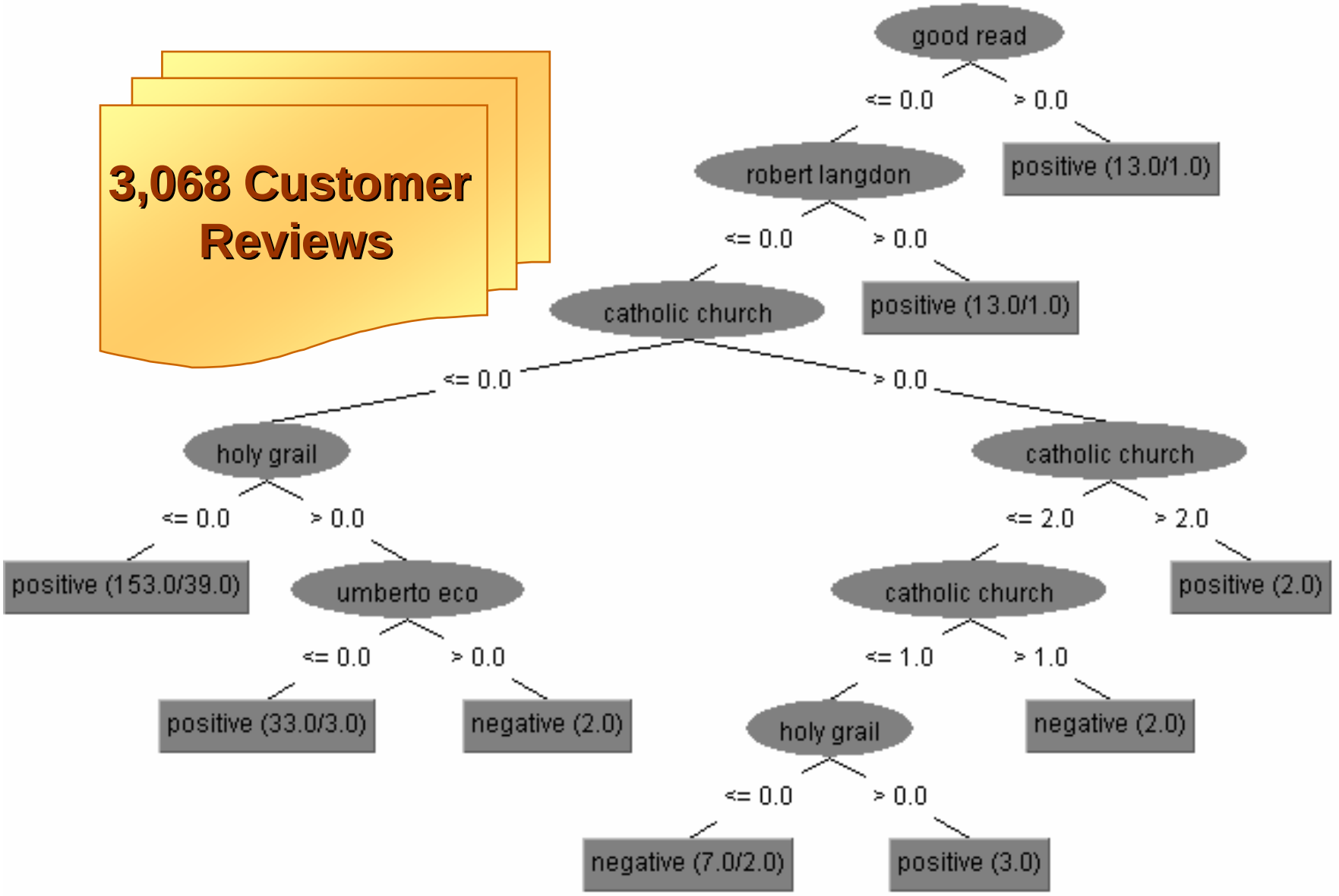
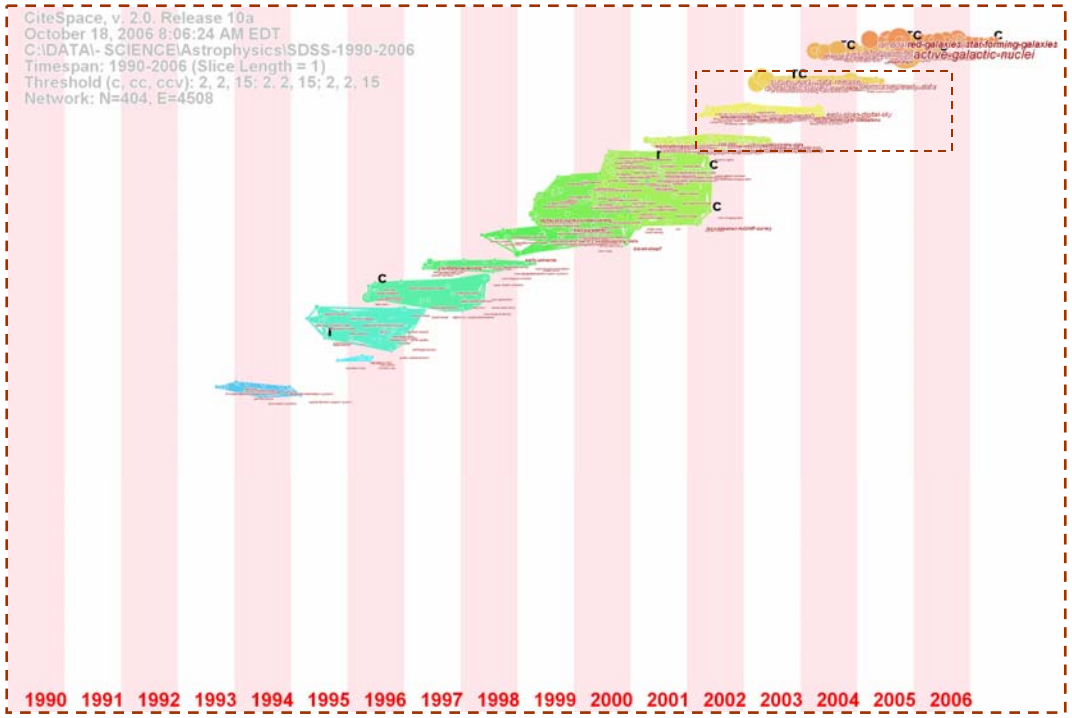
The Da Vinci Code (Amazon Sales Rank: 7)



Making Sense of Concept Change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absorption-line
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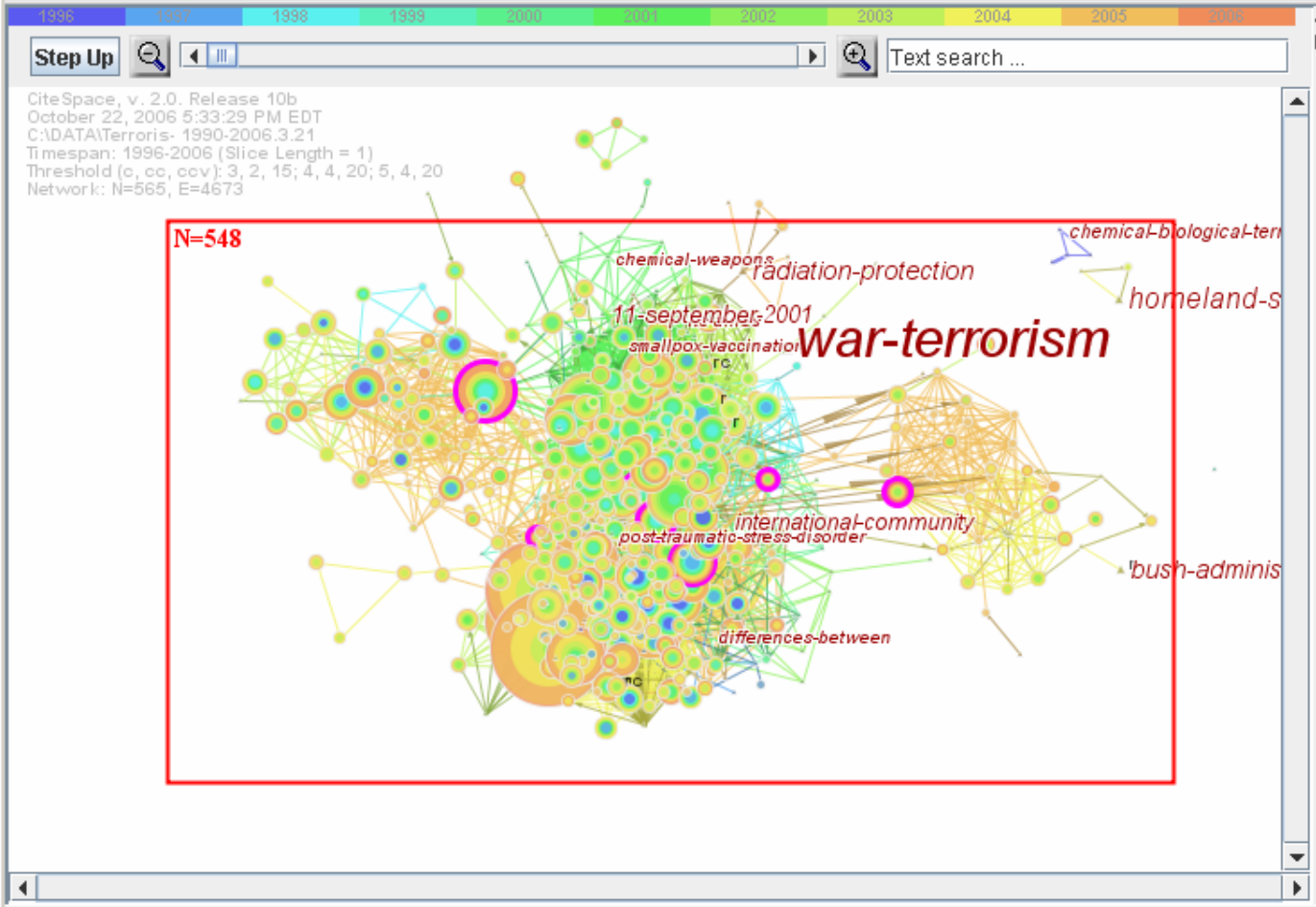

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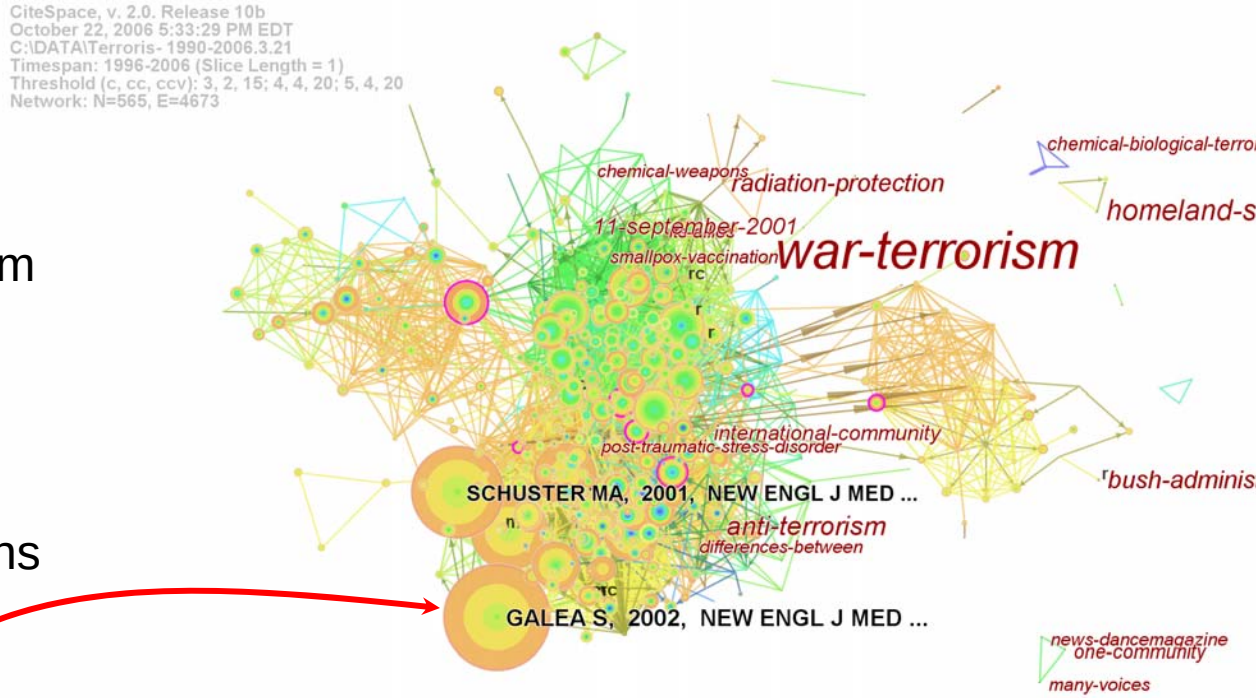
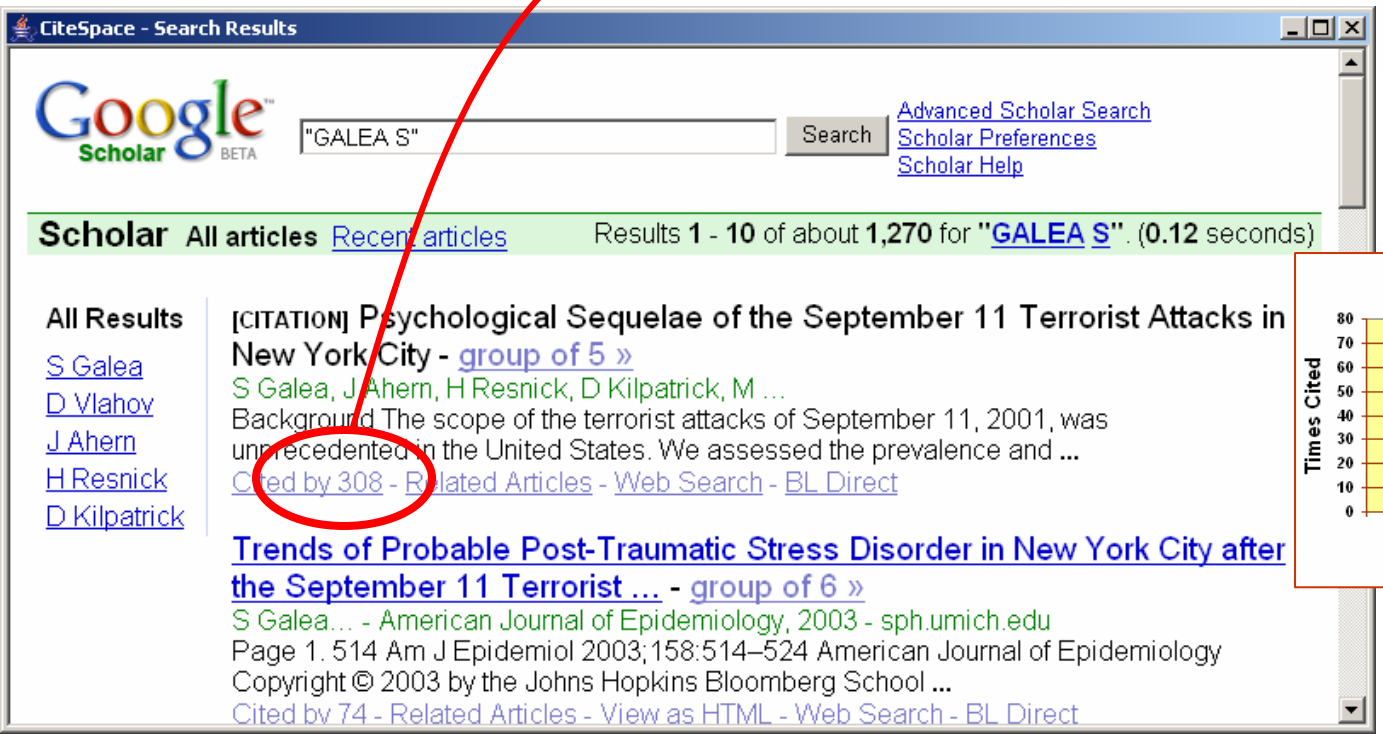
GALEA 2002

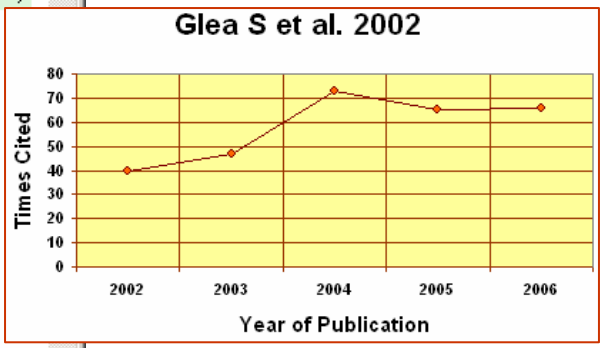
WoS: **149** Citations (as of 3/21/2006 within the terrorism data set)

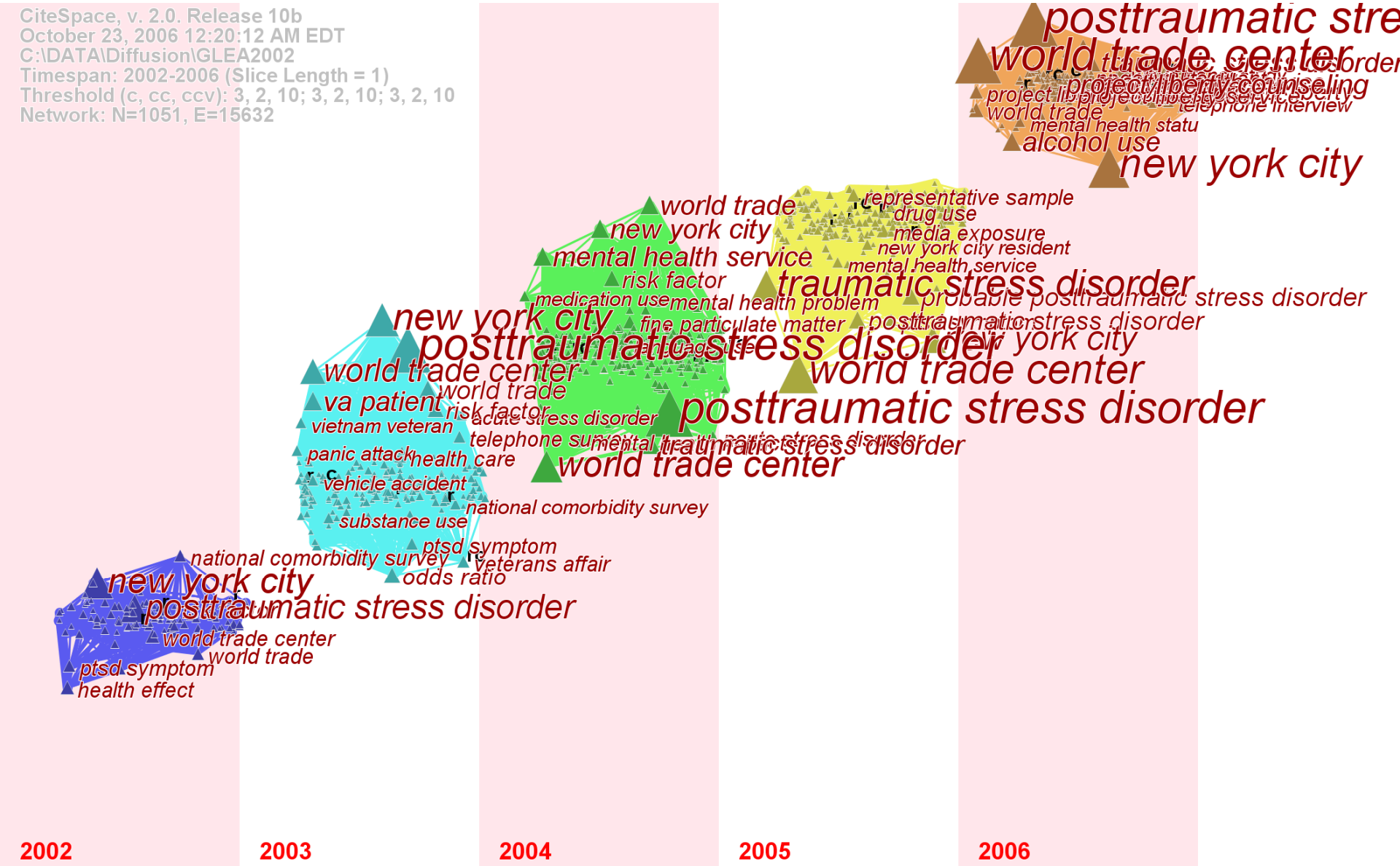
WoS: **292** Citations (as of 10/22/2006)

Google Scholar: **308** Citations (as of 10/22/2006)





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Network: N=1051, E=15632
posttraumatic stre
world trade center
project liberty counseling
project liberty service
telephone interview
world trade
mental health statu
alcohol use
new york city
world trade
new york city
mental health service
risk factor
medication use
mental health problem
fine particulate matter
representative sample
drug use
media exposure
new york city resident
mental health service
traumatic stress disorder
probable posttraumatic stress disorder
posttraumatic stress disorder
new york city
world trade center
posttraumatic stress disorder
new york city
posttraumatic stress disorder
world trade center
va patient
world trade
risk factor
acute stress disorder
vietnam veteran
telephone survey
mental health
panic attack
health care
vehicle accident
national comorbidity survey
substance use
ptsd symptom
national comorbidity survey
veterans affair
odds ratio
new york city
posttraumatic stress disorder
world trade center
world trade
ptsd symptom
health effect
2002
2003
2004
2005
2006

2002

25	new york city
22	posttraumatic stress disorder
11	risk factor
10	world trade center
10	health effect
9	ptsd symptom
9	world trade
9	national comorbidity survey
7	drug user
7	disaster site
7	vietnam veteran
7	adult resident
6	confidence interval
6	odds ratio
6	main outcome measure

2003

38	posttraumatic stress disorder
27	new york city
20	world trade center
14	va patient
13	world trade
12	odds ratio
12	risk factor
9	veterans affair
9	telephone survey
9	health care
9	ptsd symptom
8	vietnam veteran
8	substance use
8	national comorbidity survey
8	panic attack
8	acute stress disorder
8	vehicle accident
7	traumatic stress disorder
6	symptom severity

2004

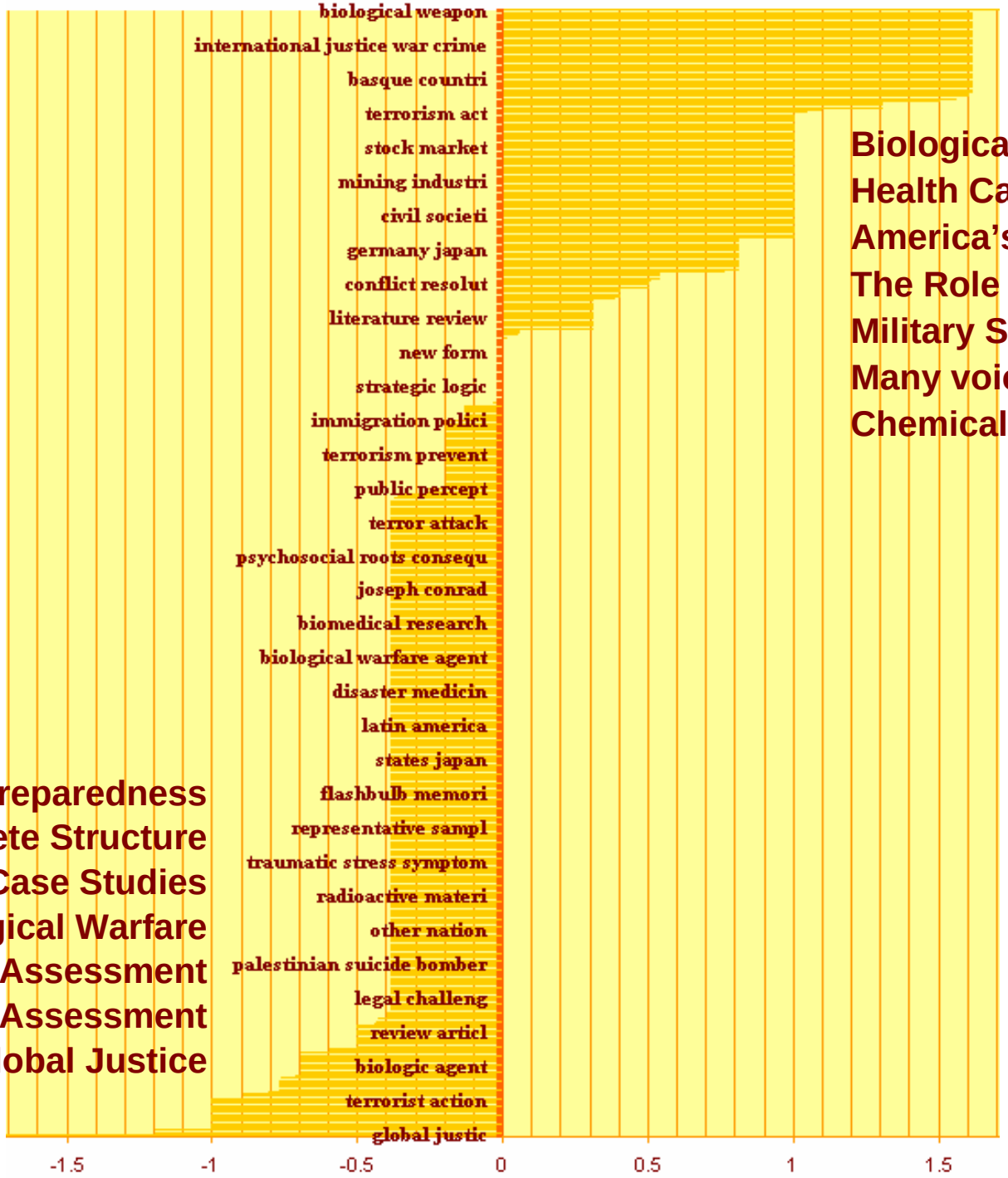
39	posttraumatic stress disorder
25	world trade center
14	mental health service
14	new york city
14	world trade
14	traumatic stress disorder
12	risk factor
10	mental health problem
10	fine particulate matter
10	mental health impact
9	acute stress disorder
8	language use
8	medication use
7	health service use
6	mental health visit
6	health care system
6	vehicle accident
6	college student
6	minority statu
6	media coverage
6	ptsd symptom

2005

32	world trade center
26	traumatic stress disorder
21	new york city
13	posttraumatic stress disorder
13	probable posttraumatic stress disorder
10	media exposure
10	representative sample
9	drug use
9	ptsd symptom
8	mental health service
8	new york city resident
6	risk factor
6	alcohol consumption

2006

40	posttraumatic stress disorder
38	world trade center
33	new york city
14	project liberty counseling
14	alcohol use
14	traumatic stress disorder
12	project liberty
12	project liberty service
11	mental health service
11	world trade
11	family member
10	project liberty crisis
9	community disaster
9	negative life event
8	service recipient
8	alcohol dependence
8	binge drinking
8	wave panel study
8	mental health statu
8	telephone interview
7	new york city adult
7	project liberty client
7	risk factor
7	center disaster
6	odds ratio
6	health service
6	indirect trauma exposure
6	ptsd symptom



2002-2003

Emergency Preparedness
Concrete Structure
Case Studies
Biological Warfare
Risk Assessment
Survey Assessment
Global Justice

2005-2006

Biological Weapon
Health Care
America's War
The Role
Military Strategy
Many voice
Chemical Weapon

Concluding Remarks

- Understanding the dynamics of scientific knowledge and emergent societal information is an increasingly common need across a wide range of domains.
- We need to understand the process itself better in order to build more effective tools.
- We need to take a holistic approach to address these issues from societal as well as individual perspectives.
- We need a critical and sustained mass to achieve this ambitious and challenging mission.
- This is a potential broad-impact area for making real changes to the way we work with large amounts of information.

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- **National Visualization and Analytics Center (NVAC)**
  - **Northeast Visualization and Analytics Center (NEVAC)**
  - **Knowledge-enabled Visual Analytics: Supporting Individuals and Terms from Analysis through Action**

Background Readings

Handout of this Presentation:

Chen, C. (2006) CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *Journal of the American Society for Information Science and Technology, 57(3), 359-377.*

Chen, C. (2004) Searching for intellectual turning points: Progressive Knowledge Domain Visualization. *Proceedings of the National Academy of Sciences of the United States of America* (PNAS), 101 (Suppl. 1), 5303-5310

Chen, C. (2004) *Information Visualization: Beyond the Horizon*. Springer. 2nd ed. ISBN: 1-85233-789-3.

Chen, C. (2003) *Mapping Scientific Frontiers: The Quest for Knowledge Visualization*. Springer. ISBN: 1-85233-494-0.